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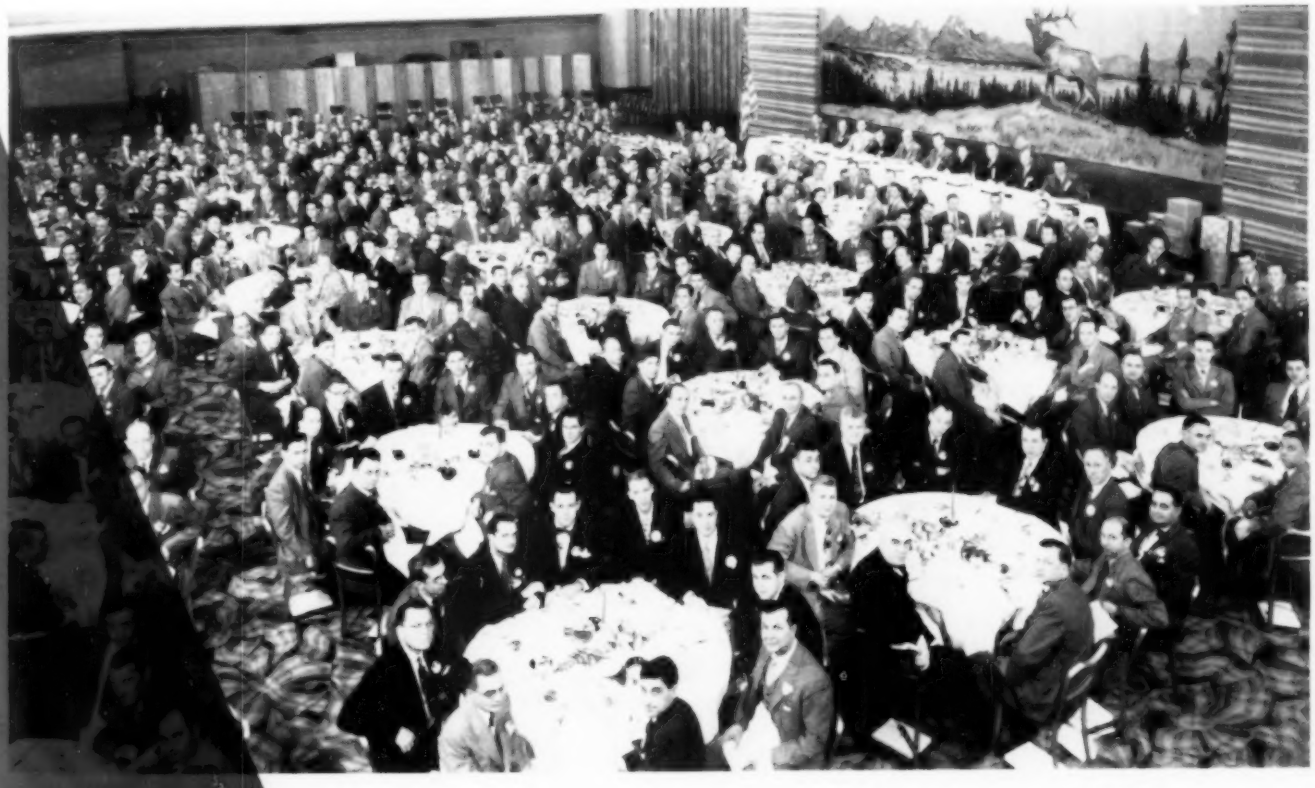

The Annual Business Meeting followed this luncheon at the 7th SPE Conference held at the Statler, January 18, 1951, New York City

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The President's Corner

COMMITTEE 61 ON PLASTICS INTERNATIONAL ORGANIZATION OF STANDARDIZATION

The National Office is very happy to report that Mr. A. J. Warner, past president of the Newark Chapter will represent S. P. E. on a subcommittee now being organized to supervise participation by American Industry and technology in the work of a committee of the International Organization for Standardization of Plastics.

This is known as ISO/TC/61. The scope of ISO/TC/61 has not been definitely set, however, when American participation was agreed upon, it was decided on the basis that the scope would be limited, for at least an initial period, to the standardization of terms and test methods and this limitation has not met with objections from the standards bodies and other countries, up to the present time.

On the subcommittee with Mr. A. J. Warner, there will be representatives from the Manufacturing Chemists Association, the Society of the Plastics Industry and the ASTM Committee D-20 on Plastics.

The Seventh Annual Technical Conference at the Hotel Statler in New York City was a tremendous success. The Conference Committee did an excellent job and the women are still talking about the wonderful time they had in New York, thanks to Saul Blitz who was in charge of the Ladies Program. Just try and keep the gals away from our next annual conference.

Irslyn Thomas

We are interested in possible sources for machinery for polishing plastics such as Vinylite, after printing. If you could put us in touch with someone making such machines we would be grateful.

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Report on the 7th SPE Technical Conference--

New York City, January 18-20

Even the weatherman conspired to help make the Seventh SPE Technical Conference the biggest yet, with warm Spring-like weather prevailing. C. Todd Clark, retiring president, summed it up best by saying "The Conference was made a success by the support of the **members,** and their attendance at the technical sessions." Total registration was well over eight hundred and there was an average attendance of 200 to 400 members at each of the technical sessions. Further support was gained through the 49 company registrations.

Officers

The national SPE officers elected for 1951 were: Islyn Thomas, President; Walter O. Bracken, Vice-President; Walter F. Oelman, Secretary; and William J. Dunncian, Treasurer.

Islyn Thomas, Newark Section, is a graduate of Johnson Tech. School, P.I.T.I., University of Scranton and Columbia University. He is president of Thomas Manufacturing Co., and vice-president of Thomas Engineering Co.

William O. Bracken, Philadelphia Section, is a member of the plastics technical service division of Hercules Powder Co. He graduated from Tufts College in Chemical Engineering, and is a member of ACS and SPI.

Walter F. Oelman, Miami Valley Section, has degrees from the University of Illinois and the Harvard Business School. He became secretary of Standard Molding Corp. in 1941 and in 1942 was appointed to his present position as vice-president and general manager.

William J. Dunnican, Rhode Island and Southeastern Massachusetts Section, served as vice-president of SPE in 1949. He started in the plastics industry with Garfield Mfg. Co. in 1918 working in the engineering department. He is now Sales and Technical Representative for Synvar Corp. on molding compounds, industrial resins, coatings and adhesives. He has served the national SPE committees on membership, credentials, finance and by-laws.

NATIONAL OFFICERS

1951 SPE National Officers: Walter Oelman, Secretary; William O. Bracken, Vice-President; Islyn Thomas, President; William Dunnican, Treasurer.

Technical Papers

Of the more than 20 papers presented at the Conference, most are printed in this issue of the Journal. Some of the papers were not available at press time, and the prize papers are scheduled for publication next month.

National Committees

Committee reports will be printed next month, too, but we can peek into that issue now long enough to see that a sharp increase in the work of the Professional Activities Committee is coming up, and that the Education group has achieved wonders. More, later!

Ladies' Program

The Ladies' program included a 'second breakfast' and style show at Altman's and a guided tour through Rockefeller Center and Radio City, and access to tickets to radio and television shows.

Conference Committee

The Conference Committee pictured above deserves the gratitude of the SPE. Their very considerable work gave us the best of meetings.

James Growley and Stanley Bindman, co-chairman of the Conference Committee, are to be congratulated for a big job very well done.

Looking Ahead

Plans for the 8th SPE Conference are well under way. It is to be held January 15-17, 1952 at the Edge-

THE SPEAKER'S TABLE

The Speaker's Table at the Luncheon—Standing are James Growley, H. V. Potter, Walter Oelman and William Dunnican. Seated: Stanley Bindman, Frank Carman, C. Todd Clark, Islyn Thomas, Bess Day and William Bracken.

THE 1951 TECHNICAL CONFERENCE COMMITTEE

These are the men responsible for the outstanding success of the SPE 7th Annual Technical Conference.

Seated (left to right): G. Palmer Humphrey, G. P. Humphrey Plastics (Company Registration); Bruno E. Wessinger, Wess Plastic Molds, Inc. (Reservations & Registration); James T. Growley, Celanese Corp. of America (Co-Chairman); Stanley Bindman, Jamison Plastics Corp., (Co-Chairman); Arthur S. Jacobs, Renwal Mfg., Co., (Program); Dr. Russell B. Akin, E. I. du Pont de Nemours & Co., Inc., (Executive Committee); and Saul Blitz, Noma Electric Corp., (Ladies' Program).

Standing (left to right): J. Martyn Voegtlen, Celanese Corp. of America, (House, Luncheon & Banquet); Edward W. Rowan, Dillon-Beck Mfg. Co., (Speakers); Arthur M. Merrill, India Rubber World, (Publicity); Samuel Silberkraus, Riverdale Laboratory, (Executive Committee & Finance-Budget); William Lewi, Dusal Tool & Mold Co. (Treasurer); Arthur L. GeWertz, manufacturers representative (Information); E. Kirby Preston, Koppers Co., Inc., (Reception); and Harold Schwartz, Empire Brushes, Inc., (Favors and Prizes).
Not Shown: Willard M. Preston, Koppers Co., Inc., (Secretary).

water Beach Hotel in Chicago. Jack Bent of Tennessee Eastman is chairman of this Conference Committee.

Plans may include sessions on special topics to be held concurrently with the presentation of the regular papers. It has been suggested that such special sessions may be (1) a presentation of papers of dealing with the chemistry and physics of plastics materials, and (2) a presentation of papers or a round-table discussion on optimum educational preparation for plastics engineering. The first is of interest to research men and chemists, while the second has special significance for educators, universities and technical schools, and to employers, as well as students looking forward to a career in plastics engineering.

THE TECHNICAL SESSIONS WERE WELL ATTENDED

THE *Injection* MOLDERSCOPE

BY A. R. MORSE

Injection Molder's Supply Co.

This is the second sample column of a possible monthly feature. If you would like to see it continued write the editor of the SPE Journal. The column will deal exclusively with injection molding machines, processes, and materials.

This month: Machinery

Deliveries on injection machines which have been running deep into the second quarter of 51 are easier. Molders are glad to accept postponement in some cases, and a phone call to the right individual at the machinery company will get you a machine quicker than the salesman would lead you to believe. However, there are not many cancellations as molders know that priorities will NOT be forthcoming for additional injection machines in event of full scale war. Manufacturers are already having their hands full getting together all the necessary parts to make a complete machine (see below). However, the acute material shortage, and the fact that molders are tying up a great deal of money in material, plus greatly increased injection machine costs have all combined to make injection machines somewhat easier to get—if you can get hold of the right party.

Injection molders have known that the 16 oz. HPM machine was a very poor fourth in the trade. But today the same machine ties for first place if it does not hold it. How come? Here we see what a company can do with a piece of injection equipment if they can overcome some of the inertia which characterizes most injection machine makers. For years HPM used a plate type cooler—and cool oil is a must on the HPM. The new machine features a Ross Cooler, and the molder does not have to add another cooler or revamp the circuit to keep the machine running. The machine has been quieted down and speeded up. And most important it features one of the longest heaters ever made by HPM in relation to the machine size. The collar type nozzle gives a good account of itself. I would rate this machine tops in its class from what progressive molders say. Credit George Kelly of Columbus Plastic Products for most of the good ideas on this successful machine.

There are complaints that one leading manufacturer of smaller size (8-12 oz) machines is shipping the machines out with parts missing. Molders get an invoice for $15,000 plus dollars and a machine they can't run because vital parts are back-ordered —and from comments one hears in the trade, they don't like it. Injection molders just don't have the kind of operation that can stand having an idle machine, as they wait to order till they have the machine booked, and they want it to run when it gets there. We all know cases where the machine has been running in 4-8 hours after it arrives in town. They also say the manufacturer is slow about getting the parts installed—asks them to do it themselves, and one gathers they don't like to finish building the machines themselves either.

Pre-Plasticizing:

Nothing is more talked about than pre-plasticizing — but one can't help observing that it is the conventional machines that are making the money even in plants with machines equipped with preplasticizers. Nothing holds more promise for getting machine costs down than pre-plasticizing, but in general, as far as we have gone today, the method has certain practical limitations. It is certainly spectacular but it seems to be harder to produce "good parts." This is due mainly to inexperience in handling hot plastic, and will be overcome. They tell us plunger pressure is not needed on the same scale, but I think they have not made up for the lower pressure yet and that as injection pressure goes down, injection speed is going to have to go up to compensate. To hold thermoplastics at elevated temperatures requires exacting controls—and more of them. When we get preplasticizing on a big scale, the heaters will be loaded with controls, and provision for cooling will be used so exact it must be. You can make the present machines with preplasticizers work today—but it takes work, real work to get everything in balance. Equipment-wise molders are watching the process, but few are tumbling yet, as they are able to compare production of "good parts" on conventional machines with the same on preplasticizers and most of them find grounds for postponing the step at the present time.

The material picture remains clouded with more acetate being molded than for a long time. Interest in drying in ovens is reviving, and the D & W Hopper Drier which uses a spreader reaching down inside the hopper to carry hot air into the material is doing a good job on individual machines. All German machines used this method of drying materials, and the observers who visited the German plants after the war all commented on the absence of drying equipment, and the use of hot air blown in at the base of the hopper instead. One leading west coast molder used this method for years before a commercial model became available. The big trick in using the D & W Preheater is to keep the material

(Continued on page 40)

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RANGES OF VALUES FROM ELECTRICAL TESTS

Dielectric Strength (D149-44)	
S/T ⅛", volts/mil	**300-400**
Dielectric Strength (D149-44)	
S/S ⅛", volts/mil	**250-350**
Volume Resistivity	
(D257-46), meg.-cms.	**10^4-10^8**
Dielectric Constant (D150-47T)	
60 cycles	**4.8-6.5**
1,000 cycles	**4.6-5.5**
1,000,000 cycles	**4.5-5.2**
Power Factor (D150-47T)	
60 cycles	**0.01-0.07**
1,000 cycles	**0.006-0.05**
1,000,000 cycles	**0.005-0.02**
Loss Factor (D150-47T)	
60 cycles	**0.05-0.46**
1,000 cycles	**0.03-0.28**
1,000,000 cycles	**0.02-0.10**

RANGES OF VALUES FROM MECHANICAL TESTS

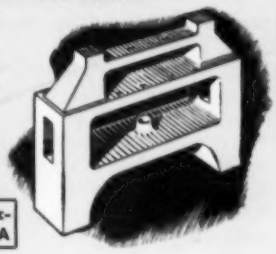
Compressive Strength (D695-44), 15,000 to 24,000 psi. **Tensile Strength** (D651-48) (⅛"), 5,000 to 7,000 psi. **Flexural Strength** (D790-45T), 9,000 to 12,000 psi. **Modulus of Elasticity in Flexure** (D790-45T), 25-35 x 10^5 psi.

RANGES OF VALUES FROM MISCELLANEOUS TESTS

Other property ranges of BAKELITE "Low Loss" Phenolics are as follows: Molded specific gravity, 1.66 to 1.92; thermal coefficient of expansion, linear per deg. C. (D696-44), 2 x 10^{-5}; heat distortion temperature (D648-45T), 230-350 deg. F.; water absorption (D570-42), per cent gain in weight, 0.01-0.07.

Address inquiries to Dept. BR-43.

BM—262 NATURAL "LOW LOSS" MATERIAL

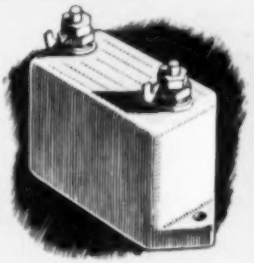


Properly molded, it is the top quality low-loss phenolic. Requires greater care in molding than other low-loss materials. Supplied on a "made to order" basis at slightly higher cost than the other materials.

Typical uses: Parts for radio receivers and amplifiers, electronic condensers, audio oscillators, signal generators.

Recommended to molders and manufacturers desiring approval under MIL-P-14A

BM—16981 NATURAL "LOW LOSS" MATERIAL



Has exceptionally good electrical properties which are retained under moist service conditions. Easier to mold than BM-262, and somewhat lower in cost.

Typical uses: Electronic capacitors, resistors, and parts for radio, radar, X-ray and similar equipment.

Recommended to molders and manufacturers desiring approval under MIL-P-14A

The black counterpart of this material is BM-17080.

BM—17748 NATURAL "LOW LOSS" MATERIAL

Has greater moldability than either BM-16981 or BM-262. Good electrical properties under moist service conditions. More stable dimensionally than most phenolic molding materials.

Typical uses: Coil forms, vacuum tube bases, condenser housings and resistors.

Recommended to molders and manufacturers desiring approval under MIL-P-14A

BM—13017 NATURAL "LOW LOSS" MATERIAL

Has greatest moldability of all materials in the "low loss" group. Has excellent electrical insulating properties in general, although not intended for high frequency service. Highly resistant to moisture. Dimensionally stable.

Typical uses: For less exacting electrical service such as automotive ignition parts and various types of resistors.

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EDUCATION SYMPOSIUM IS LIVELY TOPIC AT MIDWEST SECTION

By FRED G. WEHMER

The Upper Midwest Section has two of the members of the national educational committee in its area. We asked for the privilege of discussing plastics education and Mr. Holtby and the writer attended the section meeting held on November 13, 1950 at Esslingers Cafe in St. Paul. The meeting was a regular dinner meeting and Mr. D. S. Plumb of Monsanto was the main speaker.

Our part of the program consisted of a short history of the education committee and we told the group of the committee's recommendations. The meeting was thrown open to discussion and a very lively discussion resulted, in which most of the people attending took part.

There was considerable discussion on the subject of early specialization and it was the consensus that the teaching of basic science courses was to be preferred. One gentleman felt that the best way to obtain a knowledge of plastics was to have the student work at some plastic manufacturer's plant while going to a school, operating on the cooperative basis. Others were as sure that this approach was wrong. It was felt that a student would do well to get into summer work in plastics to acquaint himself with industry and with the practical aspects of plastics.

A number of students were present and they felt that the raw material side was neglected. Several people felt that this knowledge of raw materials was lacking in recent graduates. It should be noted that the recommended course of study does provide for information on raw materials during a student's senior year.

One of the students felt that he had learned a lot from plant trips which were arranged for them. As he put it, the things learned in school had more meaning when he found they could be applied in industry. It seemed to be the feeling that if plant trips could be arranged they had definite value in orienting a student with regard to some of the operations being used in the plastics industry.

One gentleman asked if a plastics engineer should be trained in mechanical or chemical engineering. It was agreed that this would depend on the school and also somewhat on the inclination of the man. Anyone interested in design work would no doubt stress mechanical engineering. We felt that it would be difficult to set up hard and fast rules since conditions were different in each school.

We left the meeting with the feeling that the Twin City Section agreed that the work of the committee was worthwhile and they agreed with the conclusions we had reached. In view of the lively discussion, we also felt that the time devoted to Education was well worthwhile.

It should be noted that the meeting was relatively small and the approach to the subject was very informal. We feel that a large section meeting would have to be organized with a panel of speakers to discuss the subject. The meeting should be thrown open for discussion with a member of the committee present to answer questions. Students should be invited to the meetings in order to get their viewpoints.

TOLEDO ELECTS NEW OFFICERS

By E. H. JOHNSON

At a meeting the evening of December 21, 1950, Mr. J. M. Little announced the election of the following officers for the year 1951.

President, Eric Kohler, K & M Machine Co.; Vice President, W. Fillmore, Owens Illinois Glass Co.; Secretary, D. Bowlin, K & M Machine Co.; Treasurer, F. Rosenberger, Plaskon Division, Libbey Owens Ford Glass Company; National Director, R. Dunham, Owens Illinois Glass Co.

The Toledo Section membership are fortunate in having the above named men as officers for all have had several years experience in the administration of S.P.E.

It is of interest also to note briefly the background of the new officers and how their background rounds out the plastic's picture.

Mr. Eric Kohler, known as Eric, is President of the K & M Machine Company, specialists in the design and production of plastic molds.

Mr. W. Fillmore, or just plain Bill, has been active in the manufacture of plastic parts for Owens Illinois Glass Company.

Mr. D. Bowlin, Don for short, has been active in the design of tools for producing plastic parts.

Mr. F. Rosenberger, Rosie to all his friends, is in material manufacture with Plaskon.

Mr. R. Dunham, Bob, is in development of plastics for Owens Illinois Glass Company.

The first meeting of the new year was held at 8:00 p.m., the night of January 9, 1951, at the Club Rooms of The Owens Illinois Glass Co., 2626 Dorr Street. Refreshments were served.

The speaker of the evening was Mr. John Totten of the Ford Motor Company.

Mr. Totten is a graduate of Wayne University, receiving degrees in Chemical Engineering and Industrial Management.

For the last ten years Mr. Totten has been with Ford Motor and has been active in research and development determining where and why plastics can be used on automobiles. Because of the practical experience in back of Mr. Totten he most certainly is qualified to discuss the subject he selected, "Plastic Materials for Automotive Manufacture."

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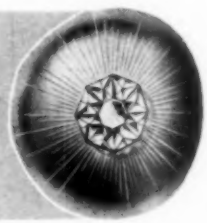

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20 Franklin Street, Brooklyn 22, New York

The Plastics Industry in Great Britain

By HOWARD V. POTTER

Chairman and Managing Director, Bakelite, Ltd.

London, England

British plans for future expansion, the present state of the plastics industry in Britain, and a discussion of the various active plastics organizations including the Worshipful Company of Horners.

During the war, plastics materials were developed almost entirely for war effort. In Great Britain practically all the plastic materials manufactured were concentrated on war production and by a careful control of raw materials, this was assured.

Owing to the scarcity of many basic materials in view of the war's large consumption, such as wood, metals, and the necessity to expand the production of all munitions of war, plastics were pressed into service for many applications which in the normal way would not occur.

To meet these heavy demands, extra plant and equipment were authorized and installed, and steps were taken to shadow certain of the equipment to minimize the risk of damage by enemy action, with the result the end of the war and cancellations of war contracts found us with equipment beyond that required for the immediate demand until new uses could be found.

The industry was faced with a major problem of finding peacetime applications to replace the wartime uses, but we were helped by a demand for everything available due to the lack of supply of most consumer articles during the war.

A further reason which put us in the position of being able to sell anything was the very substantial savings that had been accumulated in the hands of the people which they felt, rightly or wrongly, they were entitled to spend.

What was the sequence of all this? As soon as the plastics engineers could design any article of a domestic nature and get the tools made, demand came along to the moulders or fabricators for anything plastic. It had an appealing name—it was the plastics age, so let's get it.

Many unsuitable articles of poor design and shoddy production were made and sold; one cannot name any particular branch of the industry; the public would buy anything, so why not sell it. It was a very short-sighted policy. So that the immediate end-of-war slump only lasted a few months. The sellers' market, as far as plastics were concerned, was upon us, and it lasted until about mid-summer 1948.

Howard V. Potter

The non-ferrous metal position began to improve and aluminium and light metal alloys came into their own again and plastics ceased to be a substitute for many products during and just after the War.

Quite a serious situation arose with the unpleasant falling off of demand, not only at home but for export.

On top of this the public became more discriminating and began to reject plastics as cheap and shoddy owing to their experience during the post-war boom.—One heard in stores, on the street, and talking to friends—"I had a plastic showerproof, coat or curtain—it has torn badly round the stitching"—"It has faded so badly in the sun that I have discarded it." "The moulded cup and saucer I bought recently has stained, broken or disintegrated." No wonder the public were turning against us.

The slump in business was followed by the slump in profits and in some cases accounts went into the red. The Stock Market and financial papers took note of this and began writing down plastics investments. A well-known Sunday paper used the headlines—"The Plastic Bubble Bursts."

Mr. Churchill himself when he could see the end in sight advised industry to begin making its plans for peacetime as all war contracts might suddenly end. Some of the concerns in our industry took this advice and plans were made to bridge over the inevitable changes. Those that did were able to weather the storm.

There is one feature as a result of the war which faced British industry when it was over. Every concern of any value to the war effort, either did of its own accord or was compelled to make arrangements to disperse its activities in order to reduce the risk of bombing. My own Company had to disperse in four different production centers, about 100 miles apart. Its offices were dispersed into four different places, leaving only a skeleton staff in London. Our technical service men operated from their own homes so that they were never concentrated together.

Industry was faced with a problem of carrying on until reassembly in their proper quarters could take place. This added a tremendous burden on top of planning for peacetime production.

The plastics material manufacturers, not making a component or finished article had to wait on the moulding and fabricating end of our industry to effect the change-over. The material manufacturers out of their own interest, gave great assistance in tiding over this change.

The slump period remained with us well into 1949. During the intervening period, some of those who had come into the industry during the war by the encouragement of the Government department and also those who joined the industry during the post-war boom, fell by the way.

The industry was quick to realize the situation and in consequence designers were called in to improve design of articles. New and more suitable products were produced. In consequence the industry has climbed back on to a sounder footing and by dropping applications which are better made in other materials, we got back to the basis of asking ourselves —why should this be made in plastics?

The thermosetting moulding side of the industry is not yet back to its full capacity, owing now to the shortage of some basic raw materials, but generally speaking, with the newer plastics now available—vinyl, poly-

ethylene, urea, and to an extent polystyrene, plastics in Great Britain should be on the road to further expansion.

At present, we are again in a sellers' market. The rearmament in your country has materially affected supplies of some raw materials for our industry, with the result supplies are short and it would appear as if considerable curtailment of available supplies of plastics will arise in 1951. With our own rearmament program it looks as if the stage is set for reimposition of control and all the disturbance of industry it entails.

You are well aware that in consequence of the war most countries have gone "self-contained mad," and we are no exception. In England every effort is being made to try to safeguard our basic raw materials where we can and this includes the chemical industry.

RAW MATERIALS

Take a few of the basic materials as an example. Phenol—Britain has always been a producer of natural phenol. It uses gas extensively for industry and for illumination and with its steel productivity and many large coke oven plants, it has large resources of coal tar from which it produces natural phenol. The production figures of gas and coke over tar phenol run about 13,000 long tons per annum. This, however, is insufficient to meet the demands of industry as a whole, which is likely to require 20,000 to 25,000 tons or even more per annum, in the near future.

The difference between natural phenol and total required has been met in the past from a small 4,000 ton per annum synthetic plant and importation of the balance.

The future will now be taken care of from two new synthetic phenol plants, one of which will soon be in operation, the other early in 1952, so that Great Britain should be self-contained and possibly have a surplus for export later on.

It is fortunate that the production of benzol which runs at about 378,100 tons (850 million lbs.) (96 million imperial gallons) annually is adequate to take care of the phenol requirements. (Only 1¼ million imperial gallons used for plastics).

Formaldehyde which is dependant on methanol is made in adequate quantities in Great Britain; if more is required there is no great difficulty in adding to the plant.

Methanol is made synthetically in Great Britain from carbon monoxide and hydrogen and can be augmented with the addition of further plant.

Woodflour is not an indigenous product to our country; the best is imported from Scandinavia. It cannot ever be produced in Great Britain in sufficient quantities as we have not the timber.

Cotton linters is another commodity which we cannot produce and we are all well aware of the serious position in regard to supplies and price.

Urea is produced synthetically in our country and further supplies simply need the installation of further plant.

Carbide for the production of acetylene is now available as a British-made product at the plant in South Wales, which was installed during the war. The present capacity is about 200,000 tons per annum, and recently the demand has exceeded the supply and some has been imported. Being a Government-owned plant the price is controlled.

Polyvinyl chloride plastics are made in two plants but the output is inadequate at present. The supply should however take care of the demand in the future with the extensions of present capacity and a new plant which should be operating in 1952.

Ethylene as a base for the production of several plastics including polyethylene is available in limited quantities at present.

You are no doubt aware of the large oil cracking plants that are being installed in Great Britain by three concerns, two of them sponsored by big oil companies, so that in the near future ethylene and many of the chemicals accrued from the process will be available for the production of not only larger quantities of polyethylene and polystyrene, but some of those new plastics arising from ethylene.

THE FIBRE AGE

A new fibrous plastic has recently been announced—"Terylene" which is based on polyethylene glycol terephthalate. It claims to have considerable advantage over other fibres. This is now going into large scale production.

There is a large amount of research and development going on in Britain in connection with the production of new fibres;—everybody is fascinated with the problem and we may see very important developments in this field in the future.

There have been overstatements made that this is the "plastics age," but most people are developing a better perspective and realizeing that plastics have their proper place and especially their limitations. If we don't take care we will have a "synthetic fibre age" to replace it. Most of them are based on a plastic or polymer and have their origin in our industry.

The whole of the technical research, both fundamental and applied in the industry is carried on by individual companies at their own expense, i.e. by private enterprise. There is not yet a Government sponsored Research organization for plastics within the orbit of our Department of Scientific and Industrial Research.

The amount of money spent on research in the plastics industry was estimated in June 1950, according to a statement in the London "Financial Times," to be about one million pounds per annum. This estimate may be too low.

The raw material manufacturers and plastics material manufacturers being mainly chemical manufacturing companies, value research very highly, in order to ensure their position in the development of new plastics materials and applications for them.

On the fundamental side of research, the Department of Colloid Chemistry at Cambridge University works quite actively on the molecular structure of colloids generally, which includes some types of plastics materials.

The plastics industry looks after its employees by means of schemes of training, both for juniors and those intended for higher management.

The scheme for juniors is sponsored by the Joint Industrial Council for the Plastics Industry through the Association of Chemical and Allied Employers by agreement with the Trade Unions' side of the Council.

Staff Trainees for higher management are catered for by schemes organised by individual manufacturers, and such Trainees are usually drawn from University-trained young men.

What is the set-up of our industry and the organization that represents it?

TRADE GROUPS

We have **The British Plastics Federation** which is a trade organization, all embracing in its scope. It represents the industry as a whole, from the raw material suppliers to the fabricators of the finished article.

It represents about 80 per cent of the total industry in tonnage and value and is recognized by the Government departments as the official body to approach on any trade problem of the industry except labor matters. The membership is comprised of companies and firms who are bona fide British plastics manufacturers or suppliers to the industry. It is built up of different groups, each group being autonomous within the constitution. It can deal with any matters affecting its particular group, but any subject affecting another group or industry generally, must be referred to that group concerned or to the Council respectively.

There are six groups, namely:—

Raw Material Suppliers' Group

Plastics Material Manufacturers' Group

Fabricators' Group

Laminated and Fibrous Products' Group

Moulders' Group

Engineers' Group

The membership of the British Plas-

tics Federation is one of Companies and each Company appoints its representatives to act for it.

The Federation is run by the Council and its Main Executive Committee and Group Committees. It has proved to be very useful in holding the industry together as a means of contact between different interests and very valuable as a spokesman for the whole industry from time to time.

The next organization associated with the industry is **The Plastics Institute.**

This is an organization made up of persons working in or interested in plastics. It has entirely a personal membership. Companies and firms cannot be members under its present by-laws. This I view as important. It enables the Institute to be run without undue influence of industry or any group of the industry. Its prime function is to offer a platform to any of the members to present commercial and technical papers. It usually attracts large numbers to its meetings.

It also has of recent times set itself up as a qualifying body and grants diplomas, associateships and fellowships against examination or by selection in special cases. It also looks after and arranges the education side for industry and has had certain sums voted by industry for this purpose and has granted scholarships to promising young men for the Universities.

The next in importance is **The Plastics and Polymer Group of the Society of Chemical Industry.**

The Plastics and Polymer Group's main function is to provide a platform and meeting place for those interested in the chemical side of plastics. Its lecture and papers are of the more scientific type.

As its title indicates it is a subject group of the Society of Chemical Industry which has 13 Sections in Great Britain and one each in New York, Canada and Australia. It also has five subject groups which are non-territorial.

The Society of Chemical Industry publishes a weekly news journal—"Chemistry and Industry" and "Transactions" and assists in producing the British Chemical Abstracts.

The Association of British Chemical Manufacturers, as its name implies, represents concerns engaged in all types of chemical manufacture in Great Britain. It is a trade organization and is the "spokesman" for the Chemical Industry other than for wages. Its membership consists of Companies and not of individuals. The Association is divided into seven groups, one of which includes the plastics industry. The Association is not active in regard to the interests of plastics manufacturers, but looks after the interests of any other branch of the Chemical Industry. The plastics interests are mainly catered for by the British Plastics Federation.

All labor problems for the Plastics Material Manufacturers' Group are taken care of by the **Association of Chemical and Allied Employers,** which has a Plastics Material Manufacturers' Group, upon which all the plastics material manufacturers are represented.

We recognize that our side of the plastics industry is closely allied to and in fact is a branch of the chemical industry, while the moulding and fabricating end is very much allied to the engineering industry.

So here we have a "parting of the ways" and the plastics material manufacturers being allied to the Chemical Industry, deal with all operatives basic wages through the Chemical Industry Joint Industrial Council.

The Council which has official recognition as the negotiating body for settling basic hourly rates within the chemical industry, consists of elected representatives of the employers and representatives of the operative employees through their respective trade unions. The Unions are represented by their officials, usually the Union Chairman and Secretary and a few of the area representatives. The Chair is occupied in rotation—an Employer one year and a Trade Union official the next year. The Employers' Chairman is usually the Chairman of the Association and the other representatives are the members of the Executive Board.

WAGE CLAIMS

All national basic wage claims for the chemical industry or disputes which cannot be settled locally are brought up to this Joint Industrial Council and it meets as need demands to hear the case for both sides, with a view to arriving at an agreement. If agreement cannot be reached then it is reported to the Minister of Labor that a dispute exists and he usually tries to get the two sides together again to reach a settlement. Failing that, he passes the dispute to the Arbitration Court whose decision is final.

There has only been one case that has gone this far in the Chemical Industry in the last ten years. Usually a settlement is reached by negotiation. No strike of a major importance has occurred in the Chemical Industry since the Joint Industrial Council has been in existence, and it was one of the first to be set up.

The engineering side of the industry does not have the same set-up and therefore, cannot follow the same procedure. The Engineering Employers' Federation with which moulders and fabricators are affiliated, have a negotiating committee to meet the Unions and there is not quite the same conciliatory procedure.

The British Standards Institution is the body which deals with Standards for Industry, corresponding to the National Bureau of Standards, Washington. It has established certain certification marks, under which they issue licenses for use under well defined conditions.

TRADE MARKS

Just before the War, the B.S.I. registered a mark of quality (certification mark) for use in the plastics industry by all those who were granted a license to use it. The mark and scheme that went with it was worked out in conjunction with the British Plastics Federation.

Certification Mark for Phenolic Moulding Materials. The Certification Mark shows the letters B.P.F. (British Plastics Federation) and a device combining the letters B and S (British Standards Institution). The two letters AA have been allocated as a reference to one of the Licensees.

The Code A 1 indicates Type G of B.S.771 (1948); the letter A stands for BS.771. There are eight types of materials in BS. 771, i.e. Types G, GX, HD, MS, MHS, HS, HR and L and these are numbered from 1 to 8, i.e. on the Certification Mark, Type GX would have the reference A 2 and Type L would have the reference A 8.

The use of the mark and any other (under license) can only be granted where standards of quality or other conditions already exist in the form of a British Standard (B.S.).

Each applicant for a license must submit to an examination of his process and satisfy the B.S.I. that they have proper means of control within their works and will in fact carry out control tests at agreed intervals; keep records of such tests and will appoint one of their technical men to be responsible on behalf of the B.S.I. for checking and signing the tests records.

The B.S.I. have the right to send round their inspector at any time to a licensee's works and take samples, or where practical, buy articles in the open market.

Any proved infringement of the use of the mark causes first a warning to be issued by the Marks Committee of the B.S.I., upon which a certain number of representatives of industry sit, and if it continues, the license is cancelled.

So far phenolic and urea moulding materials have a British Standard and most of the reputable makers are licensees and use the mark on their standard grades of powder.

There are as yet only a few specifications available for mouldings, such as picnic ware and toilet seats, but others are in the process of being developed, including specifications for P.V.C. articles and laminated sheet. Both of these products are expected to

be available for issue of licenses in the near future.

This step is important as it should ensure a high quality range of products and enable the purchaser to have some guarantee of the quality he is buying, and perhaps convince the public that plastics are not shoddy articles but products that can be relied upon.

The group of licensees are proposing to publicise this Certification Mark for plastics in 1951 with the backing of the British Plastics Federation.

We should do all we can to improve the quality, the design and the utility of plastics by all the means at our disposal, and I consider you in the United States have done much to help uplift the quality, grade and design of plastics products, even more than we have in Great Britain.

There are two other bodies which are associated with plastics.

HORNERS AND P.I.G.S.

You may know that in the early days in the larger towns in England and in London in particular, trades and crafts were organized into Guilds which became very powerful and rich bodies. Many of them obtained Charters from the King of the time which gave them a monopoly of their particular trade, provided they set up standards of quality or measure and took steps to enforce them. This they partly did by having a "closed shop" as far as their particular trade was concerned, and no person who was not in the respective Guild could trade within the sphere of their jurisdiction.

They were and are known as the City Craft Guilds. Now, one of these was called the Worshipful Company of Horners. The Craft made all the transparent window panes before glass was available by beating out horn so thin that it was transparent yet thick enough to fit in a small pane in a window (incidentally, the origin of the small pane window).

Members of the Horners' Company made all the drinking horns, powder horns and combs of horn which was quite a flourishing business until the production of glass put them out of the window business and porcelain and china out of the drinking horn business.

Nevertheless, the Guild remained in being. It has certain assets and properties which it had acquired in the earlier and more wealthy days.

A few years ago the Court of the Guild conceived the idea that, in order to preserve continuity and with the thought behind it of linking the ancient with the modern, invited certain persons in the plastics industry to become Liverymen of the Giuld. This was readily accepted so that the Ancient Guild of Horners who worked very much in the early plastic material, has assured the continuity of their honourable Guild by linking up with the plastics industry.

The Guild meet annually to have an address from some prominent member of the plastics industry and to attend their annual banquet.

The Guild has gone further and granted a cash prize for competition among employees of firms which are members of the British Plastics Federation, for a finished article made in plastics, the Federation deciding each year the class of article that must be submitted.

The foundation of the Horners' Company goes back earlier than 1284, and the charter as a Guild was granted by King Charles I, in 1638.

As the immediate past Lord Mayor of London, Sir Frederick Rowland, was a Liveryman of the Horners' Guild and its Master 1935-36, we were invited to hold our banquet this year in the Mansion House in the City of London, the home of the Lord Mayor.

One final but minor activity (except to golfers) is the Plastics Industry Golfing Society, known in England as the P.I.G.S.

A number of trophies and cups have been bestowed through the P.I.G.S.

RAW MATERIALS

	Available Supplies in Great Britain		Used in the Plastics Industry 1948	Percentage
	Tons	lbs.	lbs.	
Phenol	20,000	45,000,000	39,000,000	65-70%
Cresol	14,300	31,000,000	23,200,000	75%
Methanol	60,000	134,000,000	80,400,000	60%
Formaldehyde	70,600	158,144,000	110,000,000	70-75%
Calcium Carbide	100,000	224,000,000	56,000,000	25%
Casein	8,750	19,600,000	4,900,000	25%
Urea	12,000	26,880,000	18,200,000	70%
Thiourea	300	672,000	100,000	15%
Melamine	400	996,000	996,000	100%
Hexamethylene Tetramine	2,000	4,480,000	3,360,000	75%
Benzene	378,000	850,000,000	12,700,000	1.5%

	UNITED KINGDOM		UNITED STATES	
	Production p.a. (000,000 lbs.)	Production per head of Population	Production p.a. (000,000 lbs.)	Production per head of population
Phenolic Cresylic resins	57.2	1.15 lb	220	1.46 lb.
Phenolic Cresylic M.M.	60.0	1.20 lb.	171	1.14 lb.
Phenolic and Urea Laminated	17.0	0.34 lb.	*N.A.	N.A.
Urea and melamine resins	36.8	0.74 lb.	91 (estimated)	0.61 lb.
Urea and melamine	20.0	0.40 lb.	40 (estimated)	0.27 lb.
Phenolic, urea and melamine laminated	18.1	0.36 lb.	N.A.	N.A.
P.V.C. Resin and Compounds	37.0	0.74 lb.	224	1.49 lb.
Cellulose Acetate	12.4	0.25 lb.	66.2	0.44 lb.
Polyethylene resin	N.A.	N.A.	N.A.	N.A.
Polymethylmeth-acrylate resin	8.7	0.17 lb.	N.A.	N.A.
	Sales of imported polymer	Sales per head of population		
Polystyrene resin	2.8	0.06 lb.	145	0.97 lb.

*Not available

for annual competition and successful meetings are held throughout the year.

Some figures on the size and the progress of the plastics industry as a whole:—

In 1938 the tonnage was 30,000 tons (67,200,000 lbs.) 1.4 lb. per head of population.

In 1948 the tonnage output was 130,000 tons (290,000,000 lbs.) (5.8 lbs. per head of population)

It is estimated that in Great Britain the capital **employed** in the plastics industry is approximately L40/50,000,000. This figure is approximately ten times greater than it was 12 years ago.

The total of all plastics **produced** in Great Britain in 1938 was 30,000 tons, as just stated, and during the next 10 years this output grew to 130,000 tons (290,000,000 lbs.) which represents a figure of about 5.8 lbs. per head of population per annum in Great Britain.

The production capacity in Great Britain was estimated to be in 1949 about 185,000 tons and when the program of expansion is completed in 1953, the capacity will be 339,000 tons of a value of L71,000,000 (200,000,000 dollars) (@ 2.80 to the L).

Future Trends. (Expansion of the Industry).

In the Report of the Chemical Industry, 1949, it is stated that 55 expansion schemes were in progress, totalling L17,447,000. Eighty-nine expansion schemes have been applied for, totalling L21,974,000.

In decreasing order of Capital cost, the larger schemes referred to above are:—

Terylene Polymer
Cellulose Products
Polyvinyl Chloride
Polytetrafluorethylene (P.T.F.E.)

When all these schemes are working it is estimated that 4,500 more employees will be required.

It is disclosed that the further capital investment approved for the plastics industry is such that in about 1951, the total capital employed will be L62,000,000 to L72,000,000.

Now, from some calculations we have made, the following is the consumption of plastics per head of population:—

All Types:

Great Britain, 290,000,000 lbs. = 5.8 lbs. per head of population. (50,000,000 persons)

U.S.A., 934,000,000 lbs. = 6.2 lbs. per head of population. (150,000,000 persons.

	Pounds per capita Gt. Britain	U.S.A.
Polystyrene	0.06	0.97
P.V.C. Resin & Compounds	0.74	1.49
Resins (phenolic type)	1.15	1.46
Resins (urea type)	0.74	0.61
Moulding Material (Phenolic)	1.20	1.14
Moulding Material (urea)	0.40	0.27
Cellulose Acetate	0.25	0.44

While the size of the industry does not compare with yours in the United States, it is becoming a major industry and must play its part in maintaining the country's exports which are absolutely essential to Great Britain, not only to keep up a reasonable standard of living, but to maintain a population of 50 millions at all.

In the United Kingdom, phenolic and cresylic resins nearly trebled their output over the eight years under review (1941-1948) inclusive.

Phenolic and urea moulding material doubled their output over these 8 years.

Cellulose acetate moulding materials increased about five times over the last 8 years.

Acrylic sheet increased by 2½ times over the last eight years.

Polyvinyl chloride increased many times over the last eight years, certainly three times over the last six years.

Polystyrene resin doubled its consumption during 1948-49 (all however, imported into the U.K.)

Urea resins increased many times during these eight years. Great Britain is more urea conscious than the United States, the relation being .040 lb. per head in Great Britain, as against 0.27 lb. per head in the U.S.A.

The consumption of available raw materials in Great Britain in relation to the total materials available, is shown in the preceding tables.

Conditioning Phenolic Materials For Stability in Molding

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Final service conditions for the molded piece should determine the moisture content and preheat technique before molding.

Stability, according to Webster, is a vow binding a monk for life to one monastary. In plastic molding, stability is the substance of things hoped for but never in the this vale of tears fully to be attained.

Phenolic molding materials in general are subject to changes in atmospheric conditions which tend to make parts molded of these materials change their dimensions. Consequently, the manufacture of plastic parts which will maintain close dimensional tolerances involves not only the material, its molding techniques and geometry of the molded item, but also a close control of a number of other factors during the life of the parts in question.

It is well known that many plastic materials change dimensions over a period of time by various mechanisms. [1,2,3] Included are additional polymerization or condensation with their subsequent volume decrease; loss of volatile materials such as water, phenol, and ammonia; and loss of plasticizers some of which are classified as non-volatile. In addition, temperature changes affect the actual dimensions of molded parts up to ten times as much as they affect metal parts. Obviously, all of these mechanisms are affected by the atmosphere and operating conditions surrounding the molded part. If, for example, a molded part is to be exposed to a hot, dry atmosphere for a prolonged period of time, we can expect that if additional polymerization will occur,

Jerome L. Formo

higher temperatures will cause it to occur more rapidly. Hot, dry atmosphere also will increase the rate of loss of volatile materials. If, on the other hand, a molded part is to be exposed to hot, humid atmospheres, we know that the effect of the high humidity may be revealed in several different ways. First, it will increase the water content of the molded part and consequently cause swelling or an increase in dimensions.[1] Secondly, condensation of water from a highly humid atmosphere on the surface of a molded part may cause leaching of water soluble materials with a reduction in strength and an eventual reduction in size.

Condensed water on a surface is a very good solvent for many materials which are normally not considered very soluble in water. Thus, when tests are performed with parts immersed in water, it should be understood that many materials very soon form saturated solutions. In fact, much water which is used for testing becomes saturated with certain elements or compounds very quickly and the solvent action of the water is thus decreased. However, if a continuously fresh supply of distilled water is brought to bear on a part, it will have a much more prominent solvent leaching effect on the part.

In the case of a humid atmosphere, again such materials as ammonia are taken from a molded part and in the presence of water and heat it is very common to find that the wood flour used as a filler will decompose and produce corrosive materials such as acetic acid.[5] In most instances it will be noted that the first source of dimensional instability in phenolic moldings is the loss of volatiles such as water. Thus, for example, a part which has been molded with low moisture content will tend to reach equilibrium at a relatively low humidity, while a part molded with a higher moisture content will become stable at a somewhat higher relative humidity.[6] To this end, a large portion of this paper is devoted to the effects of methods used to control moisture content of phenolic materials.

Other parts of the paper include studies made on volatile loss in phenolic materials during preheating and molding cycles. Tests which were used to determine stability of molded parts include aging over a two-year period at high and low humidity levels, at a high temperature level, and at controlled laboratory atmosphere conditions.

PROCEDURE

For the portion of this work which involved measuring the effects of moisture on as-molded conditions and on aging effects, the following procedure was used. The test pieces were transfer molded in a 4-cavity mold at a temperature of 320° plus or minus 5°F. These cavities produced one 5 in. x ½ in. x ½ in. bar, one 4 in. x ⅛ in. disk, one ASTM standard ⅛ in. tensile test specimen, and one 2 in. x ⅛ in. disk. Seventeen shots were molded under each of the following conditions: 0, 20, 40, 80, and 160 drops of water per minute, dripping into the preheat oven, 180° to 230° preheat, (internal pill temperature), 1 min. 15 sec., 2 min. and 3 min. cure. Dry bulb temperature in the preheat oven was maintained at 275° plus or minus 5°F. Transfer pressure was supplied by hydraulic pump and nitrogen bottle type accumulator, and was controlled by a reducing valve at the press. The transfer pressure was varied for each of several conditions so as to maintain a constant transfer time of 12 seconds. The moisture content of the preheated pills was determined in the following manner.

Samples of the preforms to be used were checked for moisture content by the Dean and Stark procedure. For each preheat condition, test preforms were heated in the oven. The change in weight during preheat was recorded as the change in moisture and used to obtain the values tabulated. Standard ASTM procedures were used in testing the flexural, tensile and Izod impact strength, insulation resistance and dielectric strength.

For the as-molded values, five samples molded under each of the test conditions were tested and values recorded. Three each of the remaining sets of specimens were stored under the following conditions:

(1) 200°F. Oven

(2) Laboratory atmospheric conditions—room temperature maintained at 77°F., humidity varying from 30% to approximately 60% R.H.

(3) A closed container under water to approximate 100% R.H.

(4) A closed container over calcium chloride to approximate 0% R.H.

DIMENSIONAL PROPERTIES

Concerning the as-molded physical dimensions of test pieces measured at least 24 hours after molding, the following conclusions can be drawn:

(1) Mold shrinkage increases as moisture content increases.

(2) Mold shrinkage decreases as preheat temperature increases.

(3) The effect of moisture on shrinkage is less pronounced in the middle range of moisture contents investigated.

(4) Mold shrinkage decreases as cure time increases.

(5) The geography of molded pieces influences mold shrinkage.

(6) Heavy-sectioned pieces are less affected by variations in moisture content.

At a given preheat temperature, the required transfer pressure drops very rapidly as moisture increases. It appears that the pressure required for proper molding is a relative factor which depends on the degree of preheat and the moisture content. The stiffer the material placed in the transfer chamber, the greater the transfer pressure required to produce equivalent pressures in the mold cavities. This effect of moisture on moldability or flow of a given material is also true of compression molded parts.

The dimensional values obtained from this molding test indicate that given a closely controlled set of molding conditions, very small tolerances and critical dimensions of molded parts can be maintained, at least in the as-molded condition. Furthermore, our studies indicate that for heavier cross-sections somewhat greater tolerances must be employed than for thin sections.

PHYSICAL PROPERTIES

(1) Flexural and impact strengths are improved by using higher preheat temperatures.

(2) Tensile and impact strengths show a slight decrease with increased moisture content.

(3) Flexural, tensile, and impact strengths all seem to show a slight improvement with increase in cure time.

ELECTRICAL PROPERTIES

(1) Insulation resistance decreases logarithmically as moisture increases.

(2) Dielectric strength decreases as moisture increases.

The curve of insulation resistance vs. moisture content is nearly a straight line, making it possible to predict with some accuracy the electrical resistance of the material if the moisture content is known. Inasmuch as the shrinkage of a part is so greatly affected by the moisture content, it may be possible to measure electrical resistivity by measuring the shrinkage of the molded piece.

We may conclude from the above results that, for molding in which dimensional control is of prime importance, close control over the moisture content is the most important single factor to maintain. Preheat temperature is also of importance.

AGING TEST RESULTS

Aging at high humidity levels for 22 months resulted in a severe increase in length of all test pieces. The results show that increased moisture content of the molded material results in a decrease in change of dimensions under such aging. In effect we assume that a given general purpose phenolic material will absorb the specified quantity of moisture and whether it has it before or after molding should make little difference in the total. This effect from storing at high humidity, however, indicates that for parts which are to be used in service under such conditions, it is better to use high moisture contents during the preheating operation. It may be noted also that the best stability is achieved when using a high temperature preheating with a high moisture level in the preheating oven. The effect of drying conditions or low rela-

tive humidity on dimensions is quite interesting. The temperature of preheating has little affect on the change in dimensions of parts aged over a long period of time. Furthermore, it seems that at room temperature a zero moisture content would give us zero change in dimensions. In other words, the only volatile of concern under drying conditions at room temperature is water. Not only is a part more or less subject to change in dimensions at low moisture content than at high but also possibly other volatiles or decomposition products are involved in the mechanism of changing dimensions. Both curves seem to cross the Y axis at about .004-.005 in. indicating that something other than moisture content is accounting for about this much shrinkage.

The third phase of a study on volatiles from phenolics has been started which will attempt to show the relationship of such volatiles to dimensional stability. The effect of various moisture contents on test pieces exposed to laboratory conditions over a period of two years shows the tremendous effect of moisture which varies from season to season as compared with the chemical shrinkage which also occurs in this type of material. The middle range of moisture contents maintain the steadiest conditions throughout this lengthy period of test. Because of the fact that most plastics applications result in use approximating these test conditions, it is felt highly desirable to maintain a moisture level in the molding powder of from 1 to 2½%. Furthermore, the effect of aging at drying conditions as well as in high temperature conditions shows approximately no change from the as-molded tensile strength. There appears to be a slight lowering of tensile strength but this is not varied with the amount of moisture present in the parts whether preheated at 180 or 230°F. However, in either case after aging at 100% relative humidity, there is a marked reduction in strength at dry preheating conditions and a less noticeable reduction of strength after moist preheating. In the case of flexural strength it may be noted that aging at 0% R.H. and room temperature does not lower the flexural strength a great deal. Oven aging at 200° is considerably more severe. Here again, however, aging under high humidity conditions tends to show a slight improvement when the materials have been preheated under moist conditions. In any case high humidity conditioning tends to reduce flexural strength of phenolics considerably.

Aging under either drying conditions or oven conditions results in excellent dielectric strength, while aging under high humidity conditions results in very low dielectric strength. The important thing, however, is this, that after reaching equilibrium in the atmosphere at which a piece will be used the dielectric strength is no longer a function of the original moisture content but is rather affected entirely by exposure conditions, whereas in the as-molded condition the dielectric strength dropped off somewhat when molded under moist conditions. This fact is of extreme importance because it makes one question the rather broadly accepted policy of predrying material which is to be used for electrical applications. For cellulose or wood flour filled materials, this seems to be of no avail. Consequently, those who have feared the use of moisture as a preheating medium may take consolation in the fact that final results are equal no matter how the material was preheated.

In the case of insulation resistance it was found that all test samples aged at 0% R.H. as well as those aged at 200°F. have insulation resistance values above one million megohms. The pieces aged at 100% relative humidity all were reduced to from 4-7 megohms regardless of the amount of moisture initially present. Those aged at room conditions show variations over a considerable range reflecting to some degree the initial moisture content.

EFFECT OF VOLATILES OTHER THAN WATER DURING PREHEATING AND MOLDING

The phase of the work recorded in this section has been reported in a paper presented to the American Chemical Society by Formo and Dunbar in September, 1950. The work of the preheating volatiles determination was performed in a vacuum oven with suitable means for collecting gases given off during preheating. The oven of 20-liter capacity was swept at the rate of 7½ liters per minute. Supply air was cleaned of water and ammonia by bubbling through sulphuric acid. Carbon dioxide and acid fumes were removed by passing the air through an ascarite tube. Finally, the dry, clean air was heated to oven temperature by passing through a heated copper tube. The exhaust mixture of gases was bubbled through an 18-inch column of .2 molar sulphuric acid. The qualitative analysis indicated that, aside from water, only phenol and ammonia were evolved in more than trace quantities. Other material such as formaldehyde and methyl amines which might be suspected were each checked by two methods with only negative results. Phenol was determined quantitatively by a colorimetric method.[7] Ammonia was determined by a modification of the micro-Kjeldahl technique.

Phenolic preforms were placed in the oven long enough to raise the internal temperature to 160°, 180°, and 210°F. in the dry oven as well as in the presence of 40 to 80 drops of water per minute. The dry bulb temperature of the oven was maintained at 280°F.

To measure the volatiles derived during the molding operation, preforms conditioned in the same manner were subsequently placed in compression test bar molds subjected to various temperatures and cure times, holding the pressure constant at 3,000 p.s.i. in a molding press which had means for totally enclosing the mold.

Molding temperatures of 300°, 325°, and 350° were used with each preheating condition, and cure times of 3, 5, and 7 minutes were used. Triplicate determinations, each the total accumulation of four individual moldings, were used in each case since the total volatiles evolved in several cases was small.

CONCLUSIONS

(1) The only volatile products of importance to dimensional control liberated during preheating are water, phenol, and ammonia.

(2) A controlled addition of moisture to a preheating oven results in:

(a) A reduction in the time required for preforms to reach a specified preheat temperature.

(b) A reduction in the quantity of phenol liberated.

(c) A reduction in the quantity of ammonia liberated.

During molding the following generalizations may be made:

(1) Physical properties vary inversely with loss of volatiles.

(2) Phenol loss varies directly with cure temperature and cure time.

(3) Ammonia loss varies directly with cure temperature but is not appreciably affected by cure time.

(4) Loss of volatiles during molding is greatest when preforms are preheated with higher quantities of moisture added.

In attempting to set up conditions which will properly prepare phenolic materials for stable moldings, it may be seen that due consideration must be given to the conditions of service which the part is expected to meet. For normal variations in humidity and for interior service it appears evident that a normal moisture content of from 1 to 2½% provides the most suitable overall condition. For high humidity application it is generally better to use molding material with a higher moisture content while for high temperature or dry conditions it will be generally better to use molding materials with low moisture content. In cases where physical strength is of particular importance careful consideration should be given to the preheating technique employed so as to assure achievement of optimum physical properties.

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(Continued on page 38)

Report on—

Materials Supply Prospects For 1951

By Frank H. Carman

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Frank H. Carman, assistant secretary in charge of plastics of the Manufacturing Chemists' Association, said that demand is currently running well ahead of supply for almost all types of plastics, despite the fact that amounts going into defense uses are still "extremely low." He reported that several producers have indicated orders are running as much as 25 per cent ahead of production.

"The Armed Services are now taking relatively small amounts, but we know that restrictions in other materials are going to cause them to look to plastics. Many new applications will be developed, and although the Services at the present time may not be forecasting large requirements, we know from experience that they always find needs for plastics far in excess of their originally contemplated programs."

The extent to which the industry can increase production in 1951, Mr. Carman said, will depend principally on its ability to get scarce raw materials. In addition to increased military requirements for their products, plastics manufacturers are faced with growing competition for raw materials from other defense needs such as synthetic rubber, aviation gasoline and smokeless powder.

Even the controls necessary on metals affect this part of the chemical industry, he said. "For example, the limitation order on cadmium prohibits use of this metal as a stabilizer in vinyl plastics and as a coloring pigment in several polystyrene molding compounds.

He predicted that defense and most essential civilian requirements for plastics could be supplied, but that fundamental uses for plastics, raw material limitations and smaller capacity as compared with metals production would rule out any large scale substitution for other scarce materials.

A comparatively recent difficulty facing the plastics industry, Mr. Carman pointed out, stems from the fact that "it is now one of the largest consumers of chemicals, and any sudden increase in demand places a terrific stress on the chemical manufacturers.

"This is a marked change from the situation ten years ago when the plastics industry was relatively small and could substantially change its demands for chemicals without placing too great a strain on the available supply. The plastics producers today cannot make a move in the way of expansion without providing for the basic chemicals. In many cases they must go back to the ground and provide for a number of complex intermediate steps in order to bring in a substantial increase in finished plastic."

Frank H. Carman

Plastics today are consuming about 65 per cent of the total phenol produced, he said. "Roughly 40 per cent of the methanol is used for formaldehyde, of which 65 per cent goes to resins. The industry's use of a large share of the available styrene is well known. Cellulose acetate flake now takes 60 per cent of the acetic acid, and approximately 16 percent of the flake is used for plastics. Over 60 per cent of the urea, and 15 to 18 per cent of the chlorine finds its way into this industry."

Based on recent talks with producers, he said that supply outlooks for the major types of plastics are as follows:

"Phenolics—If phenol can be made available, production could be increased about 20 per cent. A moderate expansion of facilities is underway in several units and new phenol capacity should be ready by the middle of the year. Resins based on cresol and cresylic acids will not be in over-supply for some time.

"Ureas and melamines—Production in the last six months has been at an all time peak, but still short of demands. New capacity for melamine will provide more material, but it may still be short because of pyramiding demands in civilian as well as defense products.

"Polyesters — Volume is now estimated at three times that of 1949. Because of shortages of the basic chemicals (benzol, maleic anhydride, styrene, glycols) and glass fiber, the popular reinforcing material, any substantial increases in these resins will require diversion of chemicals from other less essential uses or further expansion of basic raw materials.

"Cellulosics — Production will continue to be restricted by raw materials such as cotton linters, wood pulp and plasticizers. Supply can be expected to remain tight through the first quarter with possible improvement in the second quarter and last half of 1951 as new raw materials sources come in.

"Film for packaging, even with new capacity to be brought in, will remain in critical supply most of the year.

"Vinyls—These plastics have had a phenomenal growth, particularly the chloride copolymer materials. Producers report that they have demands for every pound of resin and that consumers could use 25 per cent more than is now available. Substantial expansions are under way but chlorine availability is a threat. Foreseeable requirements for defense products can be handled without difficulty.

"Resins based on vinyl acetate (polyvinyl acetate, alcohol and butyral) are now extremely critical because of rated orders for material in the adhesive field and limited capacity for monomer production. Only the most essential civilian and defense products will be able to obtain these resins.

"Styrenes—There is very little encouragement for improved supplies in 1951. The rubber program now being accelerated will undoubtedly make the polystyrene position most critical in the first quarter when rubber production should reach a peak. There are indications that plastics may get some relief in the second quarter. International events and mobilization policy will determine how styrene plastics are to survive and prosper in the next six months.

"Acrylics—Sheet and molding materials are currently short, but suppliers are confident that war demands and most essential needs can be handled. There will be some additional capacity this year.

"Polyethylene—Almost a 100 per cent increase in production rate will be possible by the end of the year. However, potential uses in defense items together with some essential industrial products will require all the available production when mobilization really starts to roll."

After-Treatment of Molded Polystyrene

By Charles T. Snyder

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A simple immersion test reveals place and degree of strain in molded parts. This should aid the molder in setting up optimum molding conditions and kind of after-treatment needed.

Polystyrene production has skyrocketed from 15,000,000 pounds in 1943 to 256,000,000 pounds in 1950. This progress has been accomplished by numerous advancements in the manufacture of the polymer and in post-handling of the products made from it.

The after-treatment of molded polystyrene parts has contributed measurably to the growth of the industry and to increased sales volume. However, these treatments in the main have been a carry-over of previous experience in other industries. The main problem involved has been modification and adaptation of previous knowledge to a new industry and new materials. This is progress and requires ingenuity, but still these steps utilize certain hand operations which produce results immediately apparent to the eye. On the other hand, during the last two years, molders and distributors have been harassed by the crazing and cracking of polystyrene parts without apparent cause either in transit, in storage, or on merchants' shelves. At first, it was believed that inadequate packing and rough handling were responsible for this. After considerable study, however, it was learned that this difficulty resulted from the self relief of stresses within the part. Thus an intangible but very important factor was introduced which gave impetus to programs of annealing as an important after-treatment of polystyrene molded parts.

The after-treatment of polystyrene molded parts by annealing has been selected as the primary theme of this discussion. It only recently has become an important factor in the plastics industry and detailed factual data has not been readily available. Furthermore, high labor costs, material shortages, and keen competition make the annealing method of saving molded parts attractive and worthy of detailed study.

Until recently the word "stress" was strictly an academic term in a practicing plastics engineers' dictionary when it was used to denote anything other than external forces on a piece of equipment or plastic product. Very few people except those in polymer research and development groups were conscious of locked-in internal stresses in molded plastics. Only recently have strains in the form of cracking, crazing, and often complete breakup of a part been correlated with the magnitude and pattern of these internal stresses. Such internal stresses are created either by unbalanced molding conditions of time and temperature, by external loading, or by a combination of both.

Charles T. Snyder

In a transparent part, internal stresses can readily be seen when polarized light is passed through it. The lines of stresses form a rainbow pattern which generally follows the lines of the flow of the plastic. The heaviest stresses appear at points of turbulent flow, such as at the gate or at points where the flow is abruptly broken, for example, around core pins. On the other hand, the stresses decrease along planes of long flat flow. A completely stress free part will not show any pattern but will exhibit an all over grayness when polarized light is passed through it. An example of such a part is a compression molded piece where all stresses are removed before it leaves the press. In order to prevent stresses from becoming visible strains, it is necessary to eliminate or at least partially relieve the major stresses.

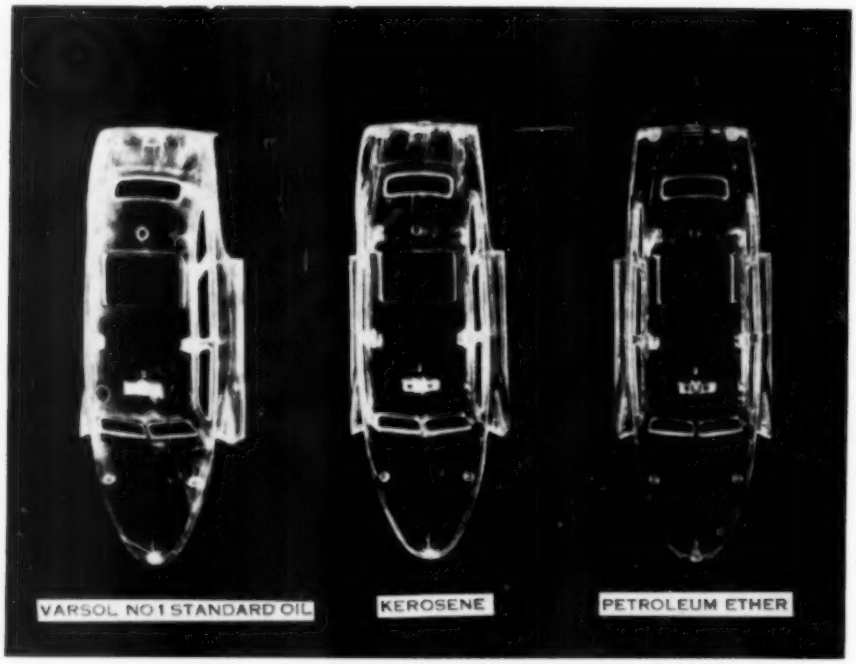
Thus annealing, which is the process of freeing from internal stress by heating and gradually cooling, becomes important. The annealing of molded polystyrene parts means to relieve, partially or totally, major stresses and strains set up in it during injection molding, machining, fabricating, or by external loading. This is accomplished by controlled heating and cooling of the part.

Fortunately, annealing of polystyrene parts is a mechanical operation and readily accomplished in practically any plant or shop. The facilities available and the plant costs will determine the method selected. While annealing of a molded polystyrene part can be accomplished on occasion in the molding machine before the die is opened, cost considerations generally preclude this practice. The effectiveness of this method will be demonstrated later.

The three most common types of equipment used to accomplish annealing successfully are a thermostatically controlled air oven, preferably a circulating type; a controlled warm water bath; and an enclosed adjustable bank of infra-red lamps.

The air oven has proven to be very satisfactory, and, inasmuch as most molders have tray driers as standard equipment, ovens are commonly used. Usually the molded products are stacked in an orderly fashion in the oven so as to permit warm air to surround the parts and provide uniform annealing. However, many times parts are stacked in a random fashion and if there is sufficient air space around the parts they will anneal properly. Usually the length of time in the oven has to be increased to permit thorough and uniform heating when the parts are randomly stacked.

When oven facilities are not available it has been found expedient to use a warm water bath arrangement. Any insulated vessel is satisfactory and for best results a bath having a thermostatically controlled immersion heater and stirrer is desirable. However, satisfactory results have been obtained when using equipment in which an immersed steam line was the heat source and the water temperature was closely controlled. Annealing is more complete and faster when



Test pieces showing cracks at points of strain after immersion treatment

parts do not touch or nest and the warm water freely circulates around them.

A third method of annealing utilizing standard equipment is by infra-red radiation. Parts laid out on a flat surface are exposed to infra-red radiation generated by means of a bank of infra-red lamps mounted above them. It is advisable to have the height adjustable in order to control the temperature. There will be less heat loss and faster annealing if the entire installation is enclosed to prevent air currents from disturbing the dead heat. A simple way of measuring temperature to insure constancy is to place a thermometer horizontally on top of the parts to be annealed.

In order to insure that stresses are properly relieved to prevent field trouble, it is necessary to evolve a fast and simple test to check (1) whether or not the part actually requires annealing, and (2) when annealing is satisfactorily accomplished. Storage tests take too long and thermal shock or cycling tests are involved and complex. Consequently, a solvent dip test has been evolved which has since proven to be satisfactory.

Earlier work in polymers suggested the use of a simple immersion test in kerosene to determine the tendency of polystyrene molded parts to craze and crack. As a result of additional investigations, other solvents have been frequently substituted for kerosene because they appear to reveal more of the hidden stresses faster.

In the present work, nine solvents were chosen. The purpose of using numerous solvents was twofold: (1) to determine the effect of various solvents in revealing heavy stresses, and (2) to determine the solvents which could be used successfully and interchangeably in the dip test. The solvents chosen were Varsol No. 1 (trade name of Standard Oil Company), kerosene, petroleum ether, a commercial cleaning fluid (Renuzit in these tests), turpentine, motor gasoline, methanol, acetone, and carbon tetrachloride.

The three solvents which did not show up the stresses in the unannealed parts were methanol, acetone, and carbon tetrachloride. Previous experience has indicated that this would happen, but these latter three solvents were included in order to demonstrate that there are common solvents which will not perform the desired function in this test. Methanol has no effect on polystyrene; acetone etches and swells polystyrene; and carbon tetrachloride is a solvent for polystyrene. However, in order to complete the test program, these solvents were used in all phases of the solvent test work. The same results were obtained on each test previously reported.

The solvent dip test used in this work is composed of three steps.

1. Cool the test parts and solvent to room temperature (70°F.).
2. Immerse the part in solvent for one minute.
3. Remove the part from the solvent and allow it to drain and air dry.

Stresses of troublesome magnitude will generally show up as strain cracks within five minutes after the solvent has evaporated from the molded part.

For these detailed studies parts were molded using a cool die to insure that the molded piece would be heavily stressed and would not have had the advantage of any one annealing. As a result, numerous heavy strain cracks developed in unannealed parts when solvent dip testing was applied.

These specimens were molded under the following conditions.

Molding Machine—8 oz. Reed Prentice
Die—Two cavity, total weight of shot=5.4 oz.
Material—Koppers Polystyrene 8X
Cylinder Temperature—600°F. front and rear
Die Temperature—85°F. front
—95°F. rear
Nozzle—Off
Injection Pressure—700 lbs.
Injection Time—12 seconds
Cool Time—18 seconds
Booster—3½ seconds
Open Time—5 seconds

The molded specimens were subjected to the following annealing conditions. After treatment they were solvent dip tested.

	Annealing Time Minutes	Annealing Temperature (°F)
Air Circulating Oven		
	15	150
	30	150
	60	150
	15	160
	30	160
	15	170
	30	170
Water Bath		
	15	150
	30	150
	15	160
	30	160
	15	170
	30	170
Infra-Red*		
	15	150
	30	150
	15	170
	30	170

*Note: Inasmuch as the infra-red annealing equipment was not totally enclosed, air currents reduced temperatures surrounding the parts thereby decreasing the efficiency of the operation.

In addition to molding parts to provide heavily stressed parts, two other sets of molding conditions were tried. First, an attempt was made to establish the highest production rate, or shortest cycle, in order to determine the effect of very rapid molding and cooling on the magnitude of locked-in stresses. Secondly, an attempt was made to set a production rate, primarily by increasing die temperatures and cycle and lowering cylinder temperature, to make parts which are reasonably free of stress before the die is opened.

A consideration of the results of solvent testing on the foregoing series indicates that:

1. Annealing temperatures are of primary importance and annealing

time is of secondary importance, but neither can be independent of the other.

2. Molding conditions are the major factors in the control of locked-in troublesome stresses in molded polystyrene parts.

3. Solvent dip testing is a fast, effective and conclusive method of testing a polystyrene part to determine whether it needs to be annealed and or whether it has been satisfactorily annealed.

The purpose of this discussion has been to present the factors involved and the advantages to be gained when annealing is used to prevent the loss of polystyrene parts. Annealing can effect considerable savings by decreasing the possibility of field complaints which lead to the return and scrapping of finished products. It does not appear prudent to overlook a ten dollar gain next week to make a false saving of fifty cents today.

RELATION OF ANNEALING CONDITIONS TO STRAINS IN PART

Material	Minimum Cycle	Annealing Cycle
Cylinder Temperature—Front	620°F.	475°F.
—Rear	600°F.	475°F.
Die Temperature—Front	85°F.	150°F.
—Rear	95° F.	150°F.
Nozzle	Off	Off
Injection Pressure	900 lbs.	900 lbs.
Injection Time	7 seconds	8 seconds
Cooling Time	8 seconds	16 seconds
Booster	3½ seconds	3½ seconds
Open Time	5 seconds	5 seconds

How Annealed	Comments
Unannealed	Badly cracked all over. Varsol No. 1 treated specimens show the most cracks and petroleum ether and turpentine the least.
Air Oven	
150°F. — 15 Mins.	Slight cracking still evident with Varsol No. 1 showing heaviest stress attack.
150°F. — 30 Mins.	Annealed—no cracks.
150°F. — 60 Mins.	Annealed—no cracks.
160°F. — 15 Mins.	Only Varsol No. 1 treated specimens show very slight cracks.
160°F. — 30 Mins.	Annealed—no cracks.
170°F. — 15 Mins.	Annealed—no cracks.
170°F. — 30 Mins.	Annealed—no cracks.
Air Oven	
160°F. — 30 Mins.	Annealed—no cracks.
170°F. — 15 Mins.	Annealed—no cracks.
170°F. — 30 Mins.	Slight cracking evident.
Water Bath	
150°F. — 15 Mins.	Annealed—no cracks.
150°F. — 30 Mins.	Annealed—no cracks.
160°F. — 15 Mins.	Only Varsol No. 1 treated specimens show very slight cracks.
160°F. — 30 Mins.	Annealed—no cracks.
170°F. — 15 Mins.	Annealed—no cracks.
170°F. — 30 Mins.	Annealed—no cracks.
*Infra-Red	
150°F. — 15 Mins.	Heavy cracking apparent all over.
150°F. — 30 Mins.	Moderate cracking.
170°F. — 15 Mins.	Moderate cracking all over.
170°F. — 30 Mins.	Slight cracking.
Unannealed Minimum Cycle	Very heavy large cracks all over.
Unannealed Annealing Cycle	Slight cracking.

Masking Problems in Spray Painting

By Hamilton E. MacArthur

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This presentation will discuss neither the well known and long established practices of masking with tape and die cut adhesives, nor with the means of decorating by silk screening, hot stamping, printing, rolling or hand worked sheet metal masks.

We shall briefly discuss the techniques which can be applied, and some of the masking problems involved, in the single and multi-color decoration of plastic parts by means of a spray gun using metal electroformed masking shields to confine the paint to a defined area.

It has been reported that 85% of all organic applications of coatings are spray applied. We hazard the estimate that an equally high percentage of all types of coatings to plastics are likewise applied. Whereas metal, wood, and other materials are frequently coated for protective reasons, it appears to us that the great majority of plastic coatings are applied for design legibility or, more particularly, decorative effect—in other words, eye appeal, which means sales appeal.

Hamilton E. MacArthur

The economical repetitious painting of like parts demands a masking shield which, first, has accuracy of form providing a snug fit over any shape or contour; second, sufficient strength at its work edges to produce sharply defined color separation lines; third, be sufficiently durable to prove capable of repeated use after repeated cleanings; fourth, be capable of rapid fitting to the part and rapid removal therefrom. It appears then that the electro-formed metal mask which is electrolytically formed upon your molded part meets all of these requirements.

Technically it does. Unfortunately however, a technically strict obser-

vance of these requisites upon any given part does not necessarily terminate in the desired production result on the whole run. The mask maker cannot be just a good mechanic. He must have some knowledge of spraying techniques to design a workable tool.

PRODUCTION COSTS

What presently concerns many of us is the actual unit production cost of spray decorating ten thousand, fifty thousand, or perhaps one million pieces. It becomes a matter of real concern when a part costs one cent to mold and two cents to decorate. This ratio is not too unusual. In fact, painting costs three times that of the part frequently occur. Various types of metal form-fitting masks can often be helpful. The term "form-fitting" is the key. At the outset it is most important to remember that such form-fitting tools cannot be made from prints or models. The tool must "form-fit" the production run parts and this can only be accomplished by electroforming metal into and upon such pieces. Tolerances not exceeding one half thousandths of an inch are often required effectually to seal against sprayed paint. Motor car, radio, refrigerator and television manufacturers usually demand such accuracy on their high priced decorative emblem and trim items. On the other hand, other less expensive consumer goods will permit several thousandths variation from piece to piece.

Because the three general types of form fitting masks have been already discussed in published literature, we shall define them but briefly.

(1) **Lip Type Mask.** Where a depressed design is to be painted the mask, besides form-fitting the contours of the part, a "lip" of metal extends down the side wall of the depression in order to trap the sprayed paint in the depressed wall. The extent of filling can be controlled within reasonable limits by the length or depth of the "lip." This same "lipping" principle is employed where an embossed design is to be protected, the "lip" keeping clean the top and all, or as much as may be desired, of the sidewall. In the first instance, free sections such as the center of letter "O" and numeral "8" are held in place by wire bridging. The same bridging is employed to hold the capping of embossed sections to be kept clean.

(2) **Plug Type Mask.** Where a depressed design is to be kept clean instead of painted, plugs suspended from wire bridging must fully fill such depressed areas to forestall paint leakage while spraying a background area. The making of such masks, to be durable for a production run, frequently requires considerable skill and a knowledge of the problems involved on a given part. When vacuum plating is a specified part of the design, plug masks are a must in order to protect those specified areas while color is sprayed upon other sections.

(3) **Block Cut-Out Plane Surface Mask.** Where calibration lines or lettering, such as appear on many kinds of dials, are too small for a practical perfect masking, a cut-out area outlining a character or group of characters is more feasible from a rapid production standpoint. By confining the paint to a relatively small area economies are achieved because fewer wiping or buffing passes are necessary to clean the pieces.

NEED FOR FIXTURES

Frequently production can be increased by using fixtures which position the piece snugly in the mask during painting. This need depends upon the nature of the piece and the extent of the area to be painted. In those instances where paint must be stopped on a plane surface having no depressed or raised line of demarkation, pressure fixtures are invariably a necessity. Furthermore, flimsy or large parts which tend to wrap or otherwise depart from their intended form require, as a rule, such pressure fixtures. It is sometimes possible to utilize the same fixture with interchangeable masks for various colors for the same job, or even with masks for an entirely different job.

Though springs, cam or toggle locking devices are sometimes preferred, experience indicates that air fixtures operated by a foot treadle are generally better. Both hands of the operator are free for productive movements, thus increasing speed of handling; furthermore the desired pressure can always be maintained, the thrust of the piston compensating for variable wall thickness of pieces or even entirely different parts. Besides this adaptability, air pressure devices can usually be produced at less cost than a comparable mechanical fixture.

One illustration will serve to point up the advantage of proper tooling. Recently a molding company was molding a 16 inch clear plastic television window and painting a three color border thereon. Their customer, the television manufacturer, had been ill-advised in supplying them with lay-on masks for spray painting the three color border. Because of inability to seal the pieces tightly which occasioned considerable wiping, the best production obtainable was 350 painted pieces per 8 hour day. Later, with adequate tooling including proper masks and air pressure fixtures, costing approximately $2,800.00 the production was immediately raised to a minimum of 750 pieces and to as high as 800 pieces per 8 hr. day. An additional saving was the elimination of one operator. One hundred twenty per cent production increase with one less person is truly significant.

SOME PROBLEMS AND SUGGESTIONS FOR CORRECTION

(1) The chief basic headache in masking is occasioned by the dimensional inconstancy of successively molded parts even under the best of conditions. Because several cavities are made from the same hob it does not necessarily follow that masks will be interchangeable on all the parts. A metal mask is not elastic. If it fits one piece perfectly and not another, nothing further should be required to prove a dimensional, or possibly form contour, variation. Multicolor fine detail work as seen on automotive and refrigerator emblems invariably require sets of masks for each cavity. We suggest this probability be considered in your finishing cost estimates for similar work. Some firms heat cure the molded pieces, not only to relieve stresses to avoid paint crazing, but also to insure a more uniform shape for better masking fit. However, with many other items, toys particularly, sufficient latitude is usually permitted to allow the masks to be made so as to compensate for some variation in the molded pieces.

(2) Unfortunately, the dimensional variations apparently inherent in the material and the manufacturing processes are more often than not aggravated by other conditions. The mask maker fits the piece sent him. Therefore, only good production run approved parts should be utilized for mask making. After the masks are made any of the following may defeat the best efforts of any mask maker:

(a) Changing the amount of load, temperature and or molding cycle. This invariably causes trouble.

(b) Changing the molding material.

(c) Re-working or re-gating the mold.

(d) Transferring the mold from one machine to another.

The above are not always fatal, but again it is well to remember that masks should be made from good approved production run pieces.

(3) Frequently, the design of the part in view of the particular color scheme to go on it makes for difficult and costly masking. We know the molder and color finisher usually have little control of this situation. Often slight changes in the mold providing for good mask sealing and sequence of colors saves many finishing dollars. It is encouraging to note that some industrial designers are aware of this and consult the mask maker before the part is put in final drawings.

In general try to avoid painting small intricate detail a color contrasting with that of its immediate background. If this cannot be avoided, plan to paint such detail first, then the following color masks can have openings wider than the actual paint

SPECIAL PURPOSE MACHINES AND EQUIPMENT

separation line, permitting more spray ings before mask cleaning. Even though the second color backs up the first this is not as a rule harmful. There are times when painting small detail last is advantageous. Such is the case with metallics because they fog more readily than lacquers or enamels.

Still keeping the design of the part in mind, it is generally preferable on smaller pieces to paint depressed or lower levels first rather than the raised areas. Here "lip" masks are used and you are consequently spraying from behind the sealing edge of the mask and not against the sealing edge as occurs with the plug type masks. Nevertheless plug masks have their uses even on small pieces, particularly where the depressed design in a clear plastic part must be kept clean for edge lighting, metallic spraying or vacuum plating. Also on large parts plug masks are helpful because the plugs, being suspended from wires, can move slightly to compensate for dimensional variations.

Again keeping design in mind, very shallow depressions having wide angle draft are difficult to seal tightly with plugs. If possible depth should not be less than 1 32 inch so the plug can have some body to it. If the design has several colors with at least two of them well segregated, the masks can be made to permit spraying the second color immediately after the first, and while it is still wet. This is particularly advantageous with automatic spray painting machines.

Where toy animals and dolls are molded in half, cemented together, and then painted front and back it is highly important that dowel pins accurately align the halves for the cementing operation. This calls for well designed cementing jigs. Misalignment of the halves will defeat good painting registration of the front and back of the part. So also will a protruding cement seam.

(4) A word about the spray department. Many plants look upon it as purely a necessary evil and treat it like an orphan. Many jobs are spoiled right here. Spray guns are one of the cheapest investments in good painting which can be made. The wrong gun for the job can waste many dollars in paint, increase rejects and cause unnecessary mask cleaning. Selection of the right gun, correct size of fluid tip, needle, and proper air cap, considering the job at hand and the nature of the paint to be sprayed will pay good dividends.

Furthermore all jobs are not to be sprayed with the same atomizing pressure and paint viscosity. There is no excuse for not determining, and then maintaining, the same viscosity on each subsequent batch of mixed paint. Be sure the operator does not use a larger spray pattern than necessary to cover the work. Besides wasting paint it will unduly load the mask. An unskilled operator can blow or flood paint past the best mask made. May we suggest all operators receive some instruction in proper gun handling.

AUTOMATIC SPRAY PAINTING MACHINES

Automatic spray painting machines are not new, but usually they have been built for a specific job or a limited classification of jobs. Within the past year there have been placed on the market machines flexible enough to paint a variety of small parts on a mass production basis. The machines are entirely operated by air and hydraulically controlled. Spraying is from underneath against the parts. The electro-formed masks fit flush with the machine table and parts are loaded manually by the operator. The spraying is automatic, but the speed of the cycle is controlled by a dial upon the control panel. In other words, the rapidity of painting is readily adjusted to suit the nature of the part being painted and also the speed of the operator. As she gains skill production is rapidly increased. The operator loads with both hands thereby immediately doubling her normal production. Production rates up to 3,600 pieces per hour are possible. Down time for changing masks will somewhat reduce the net of finished pieces.

With parts requiring bridging to hold the loose centers, shading will occur with guns in fixed position. Therefore one type of machine revolves the masks 180 degrees plus during the painting operation to circumvent such shading. Where long parts are to be painted such as automotive dash board grilles or plastic television panels another type of machine travels the guns the length of the work during spraying. One or two colors can be applied in these machines.

A third machine has a rotary work table which indexes to fixed positions for painting. One to three colors can be applied with this rotary indexing machine. Another feature of all the machines is dial control for the length of time the guns are open. This permits quick adjustment to get the amount of paint coverage desired. Once the gun pattern and the paint flow is set by a supervisor, unskilled help can be used for loading. Besides production increases obtainable, considerable paint savings are also enjoyed. It is obvious that a variety of parts can be painted by merely changing the masks and resetting the guns. In other words, the machine does not have to amortise itself on one job. One manufacturer using a rotary indexing machine reports painting 22 completed animals both sides, with three colors, each minute. Here is color painting at better than thirteen hundred per hour.

Some machines have been privately built incorporating washing of the masks after each use.

In conclusion may we again remind all finishers that labor is never amortized no matter how long the run. Proper tooling for paint finishing will save you dollars.

Wilson President

The M & W Company of 142 Central Ave., Clark Township Rahway, New Jersey announces that Mr. **James S. Wilson**, former Manager of Plastic Machinery sales for Watson Stillman Company of Roselle, New Jersey, will direct, as president, the promotion of Automatic Moulding Machines produced by the M & W Company.

Mr. Wilson resigned his position with the Watson Stillman Company of Roselle, New Jersey on January 20, 1951 to take over his duties with the M & W Company.

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TEFLON—Molding and Extrusion

By David D. James

Polychemicals Dept., E. I. Du Pont
626 Schuyler Ave., Arlington, New Jersey

Teflon can be compression molded or extruded by screw or ram. Techniques are unusual and production slow for this remarkable plastic which is in increasing demand.

"Teflon" is one of the most unusual plastics developed in recent years. Its outstanding properties have led to its use in fields never before open to plastics. These properties include resistance to high and low temperatures, unusual chemical resistance, excellent electrical qualities, and non-adhesiveness. For example, service temperatures up to 500°F are possible; even after one month at 570°F only a 10 to 20 per cent loss in tensile strength has been noted. "Teflon" is resistant to all chemicals except molten alkali metals, and fluorine gas under certain conditions. Excellent electrical properties are shown by the fact that "Teflon" maintains a power factor of less than 5 ten-thousandths over the entire frequency range now in use, from 60 cycles to 30,000 megacycles.

"Teflon" is the trade mark for polytetrafluoroethylene. It is produced in the form of molding powder and several types of dispersion. The molding powder is white in color and is made up of very small and random-shaped particles, whose size is on the order of 30- to 50-mesh.

Newer forms of "Teflon" consist of stable aqueous dispersions of the polymer. These dispersions are hydrophobic colloids with negatively-charged particles, and contain small amounts of a wetting agent to increase their stability. They tend to settle if they are allowed to stand for a long time or if they are heated to about 160°F, but mild agitation will effect a redispersion. Dispersions of this type have made possible new techniques of coating and impregnating that were previously impossible.

Another form of "Teflon," derived from dispersion, consists of very fine particles mixed with a volatile lubricant. This polymer looks like molding powder but feels slightly wet to the touch and can be squeezed by hand into a smooth, thin film. This material can be ram-extruded, after which the volatile lubricant must be driven off and the polymer then sintered.

These are the various commercial forms of "Teflon." From the molding powder, simple shapes can be molded; rods and tubes with heavy walls can be extruded. Tape as thin as two mils can also be produced. Electrical

David D. James

conductors can be coated by screw extrusion or by several methods employing dispersions. Also, certain materials can be coated or impregnated by dispersions.

"Teflon" products have a wax-like surface and vary in color from chalk white to gray. Parts cooled in the presence of oxygen remain white, while those cooled without oxygen turn gray. This accounts for the fact that individual pieces may differ in color. But color variation does not affect the physical or electrical properties of the "Teflon."

The handling of "Teflon" molding powder is somewhat similar to the techniques used in powder metallurgy. Unlike conventional molding compounds, "Teflon" does not become gradually softened as it is heated but undergoes a transition from the normal crystalline state to an amorphous gel at 620°F. "Teflon" is therefore preformed at room temperature, sintered above the gel temperature, and then cooled.

In the preforming operation powder is screened into the mold, raked to ensure subsequent uniformity of pressure, and then compressed under 2000 pounds per square inch.

A loader can be used to screen quickly and with uniformity. "Teflon" powder is introduced through an opening in the top, and then the hand crank is turned. The blades break up any lumps and force the powder through the screen and into the mold. The cap prevents powder from entering the core. The hollow core enables uniform heat to be applied to the inside and outside of the "Teflon" section during the subsequent sintering, or fusing, of the compressed particles. This core also promotes more uniform cooling of the sintered piece. Thin sections designed with no core allow sufficient heat transfer to sinter and cool uniformly.

Usually a weighed charge is used, so that the final piece will be of the proper dimensions. The powder is compressed to ¼ its volume during preforming. This compression makes necessary the use of presses with sufficient opening to accommodate the longest piece to be molded. Furthermore, mold extensions are often required during the initial filling. Initial preforming can be done in one press and final preforming in a second press, if desirable. However, once even the slightest amount of preforming is done, no more powder can be added, as cracks will appear in the finished piece between the initial and added charge of "Teflon." Automatic pelleting has been used on some small pieces.

SMALL PIECES

Small pieces made up entirely of thin sections are removed from their molds and sintered at 700°F for ½ to 6 hours, depending on the size. When a section exceeds 2 inches, it is left in its mold, heated for 2 hours at 580°F to obtain uniform temperature through the piece, brought up to sintering temperature during another 2-hour period, and sintered for 8 hours at 700°F. The end caps on the mold are left free while the mold is in the oven, so that the "Teflon" is free to expand during sintering.

Sheets and small pieces of "Teflon" can be cooled under atmospheric pressure. Larger pieces are generally cooled under 2000 pounds per square inch for 1 to 5 hours, while still in the original mold. A water spray is usually applied to the outside of the mold for several minutes at the start of the cooling cycle. A special press is sometimes desirable for removing the cooled piece from the mold.

Small pieces and sheets are sometimes coined while still in the gel state, to gain greater accuracy of dimensions. When coining several pieces at the same time, the operator must move them from the oven and line them up in the press very rapidly.

so that the coining press is closed before the "Teflon" cools below the gel state. The platens are cored for cold water. While the pressure is applied, the pieces are cooled by the platens in one to two minutes. By coining, accuracy of plus or minus 15 thousandths is possible on a diameter of two inches, and plus or minus 30 thousandths on a length of 2½ inches. The procedure of coining cannot be used to change the shape of the preform more than slightly, and no methods have yet been developed for providing undercuts and for anchoring inserts.

Exhaust ducts are used at all points where "Teflon" is at elevated temperatures, because "Teflon" gives off gases that are hazardous to breathe when the polymer is heated near or within the gel range. Very small quantities of fumes are given off at 480°F, and appreciable quantities appear when the "Teflon" is heated above 600°F. Ducts should be connected to an adequate exhaust fan to draw the fumes outside the building. Proper precautions can ensure completely safe operating conditions.

SCREW EXTRUSION

Screw extrusion of "Teflon" powder is unlike the conventional extrusion technique in which plastic is heated as it is conveyed forward by the screw. While in the gel state, "Teflon" must not be subjected to mechanical working, for this will cause cracking of the finished piece. For this reason, the screw is used to compact the powder while still cold, and the powder is then forced through a die having a long land, in which it is sintered. Die temperatures between 700 and 800°F are used, depending on the rate of extrusion. A special metering hopper is used to overcome the tendency of the powder to stick and lump. Pre-baked molding powder may be used to aid feed in the hopper. Pre-baking hardens each particle so that the powder is freer-flowing. The extrusion rate is determined by the speed of the metering screw in the hopper. The extruder barrel is grooved at the back in order to obtain a more positive thrust on the powder. The extruder screw is generally operated at a constant speed of about 5 revolutions per minute.

Dies from 9 to 36 inches long are used, depending on the size of rod being extruded. A brake is often applied to the rod at the exit to help maintain back pressure. Rods can be extruded in a multiple die. Five or six 5/16-inch rods have been extruded at one time, and even three 1-inch rods at a time have been produced. A 2-inch extruder will produce a maximum of 45 pounds in 24 hours.

Essentially the same method is used to produce "Teflon" tubes with a heavy wall. A spacer is placed between the extruder and the tubing die. This plate contains a circle of holes located on the root circle of the extruder screw. The plate is threaded to hold the mandrel which forms the inside diameter of the tube. The plate forms a breaker through which the compacted powder will pass and re-form. The material is able to re-form without subsequent cracking because practically no slippage occurs in the direction of flow. As in the case of rod, the "Teflon" tube is sintered as it is slowly forced through the long land of the die.

RAM EXTRUSION

Another method used to produce rod is ram extrusion of granular polymer. Ram extrusion is less expensive to set up than screw extrusion, and operates at greater rates. Since the ram process is a recent development, rod under ½-inch in diameter and tubing have not yet been made to any extent. Current experimental work indicates that the ram extrusion process may soon be considered as versatile as screw extrusion. Ram-extruded rod is more flexible than screw-extruded rod, as it is less oriented during production.

In this method, powder is fed into the hopper, compressed as the ram is advanced by the air cylinder, and sintered as it is driven slowly through the heated die. A plug is used in the die at start-up to maintain back pressure. Wall friction is usually sufficient during operation so that braking or spring loading the extruded rod is unnecessary.

A typical cycle is as follows: the ram is withdrawn for 12 seconds, during which a charge is metered in by hand or by means of a vibrating hopper; then the ram is advanced a distance of 4 inches for 40 seconds under a pressure of 320 pounds per square inch.

It should be noted that the wall thickness of the extrusion die is built up with aluminum tube in order to ensure uniform heating throughout the length and periphery of the die. Furthermore, the larger diameter allows heater bands of higher wattage to be used to maintain die temperatures of about 725°F.

Rods 1½ inches in diameter have been produced by this method at 34 inches per hour, or 19 pounds per hour. One-inch and half-inch rods have also been made at even greater linear rates.

ELECTRICAL USES

Three general methods are used for coating electrical conductors with "Teflon" depending on the thickness of the coating. Coatings less than 10 mils are applied by multiple dip-coating in specially-formulated "Teflon" wire enamels based on dispersions. These coatings always require subsequent baking. Thicker coatings, from 10 mils to about 60 mils, are applied by ram extrusion of a lubricated extrusion powder of "Teflon." This latter method is new and still under development. Lubricated extrusion powder is first screened into the preform cylinder. The preform is then produced by little more than manual pressure on the end plates. A rod is kept in the center of the cylindrical preform, in order that the wire may be guided through the slug easily. Two-piece preforms do not appear very practical; once again, cracks may form, after sintering, along lines produced by the planes between preform slugs. This characteristic limits the length of wire that can be handled, as the wire must always be broken between preform slugs.

After the preform has been placed in the cylinder, the wire is strung through the whole system. The ram is then advanced by the screw press. Ram speeds are of the order of inches per hour. The cylinder is not heated in any manner, but local heat is applied to the die in order to give the "Teflon" a smooth surface. The die temperature should be kept between 140 and 200°F.

As the coated wire comes out of the die, a micrometer can be used to measure the outside diameter, but care must be taken not to squeeze the coating, which is still soft. The wire next passes through a vaporizing oven, where the lubricant is driven off.

SINTERING OVENS

The vaporizing and sintering ovens are constructed in sections of tubing made from aluminum rod drilled through the center. These tubes have inside diameters of one inch and outside diameters of three inches. The comparatively large outside diameter accommodates heater bands of sufficient wattage to hold the desired temperatures. End caps are generally used when wire is coated, in order to restrict the oven entrance and exit. Tubing and shapes of larger outside dimensions than the coated wire are made without end caps. The temperature used to vaporize the lubricant, usually around 550°F, depends on the wire speed and the thickness of the coating. Too low a temperature fails to remove all the lubricant, and it becomes baked into the insulation in the next stage. If this takes place, the final "Teflon" insulation will not have the electrical and physical properties it should have. Too high a vaporizing temperature causes the coating to start sintering in the first oven, with much the same result. The second oven is set around 750°F. This oven sinters the "Teflon" insulation. No quench bath is used when the wire leaves the ovens. The wire is taken over draw-off rolls, or a capstan, to the wind-up.

Horizontal operation of such a process has so far been found impracticable, but vertical extrusion both upward and downward is possible. Although the vaporizer should normally be twice the length of the sintering oven, some extruders have been set

up with parallel ovens of the same length with a sheave between ovens. The "Teflon" coating will not crack between ovens if a large enough sheave is used.

The wire rate on this process is limited by the lengths of the ovens rather than by the extruder. Furthermore, the thickness of coating is not limited by the extrusion process, but by the ability to remove lubricant without sintering the "Teflon." This type of experimental extruder has been capable of coating wire at a rate of 5 feet per minute. Improved equipment now being built is designed for rates over 15 feet per minute. The maximum length of wire that can be coated depends on diameter of wire and thickness of coatings. Equipment now in use is designed for a 3- to 5-pound charge of lubricated extrusion powder, about 80 per cent of which is "Teflon."

Small rods and tubes can also be made by this process. Up to the present, however, production has been on an experimental basis only. The greatest difficulty encountered is the handling of the "Teflon" in the ovens, as unbaked material has low tensile strength and vaporized "Teflon" has even lower strength. Therefore, material must be supported throughout most of its length, and special care must be taken in passing the material between ovens.

The final method for coating wire with "Teflon" is restricted to heavy coatings and consists of screw extrusion of granular polymer. This method, the oldest one for covering wire, is similar to screw extrusion of rod, which has already been discussed. The die is usually set at a 45-degree angle to the axis of the barrel. The wire is pulled through the die only by the extrusion pressure. As in extrusion of rod, the screw compacts the cold polymer until it enters the long-land die, where it is heated to sintering temperature.

The extruder screw is operated at about 5½ revolutions per minute, but the extrusion rate is again determined by the speed of the hopper screw. Dies over 2 feet long are used and, consequently, very slow rates are achieved. Six feet per hour is about the maximum rate to be expected by this method.

In reviewing the various techniques we have discussed, it should be apparent that most of the currently-recommended methods for molding and extruding "Teflon" are relatively new. Some we have mentioned are still in the development stages. Great improvements have already been made in methods of handling "Teflon," but current work promises even better methods in the future.

Although fabricating techniques are unusual and production rates relatively slow, the remarkable combination of properties possessed by "Teflon" has caused a constantly-increasing demand for this product. Wire-coatings and electrical tape of "Teflon" have very good temperature-resistance and excellent electrical properties, even at high frequencies. Chemical resistance has also made "Teflon" a new and interesting candidate for gaskets, packing, and liners. Breadmaking dough rolls and heat-sealer jaws are examples of applications of "Teflon" where non-adhesion is important. These are only a few of the growing list of uses for "Teflon." "Teflon" is rapidly gaining a place as an essential industrial plastic.

Plastisol Molding

By C. W. Patton

Union Carbide and Carbon Corp.
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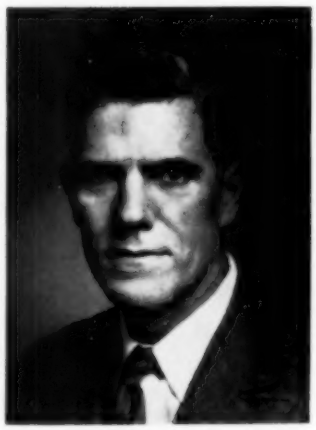
Plastisol molding offers a simple method for making complex pieces at low cost. Coloring is easy and the molding process requires no pressure.

Plastisols were first used on a large scale in the United States in 1944 to fill voids in electrical cables for use in naval vessels. Subsequently, they, and particularly the allied dispersion resin products, organosols, have expanded very rapidly into the cloth coating field. Today a large, if not the major portion of the fabrics used in the so-called artificial leather field are coated with organosols or plastisols. Other important present day uses for plastisols include coated materials for wall and floor coverings, venetian blind tapes, coatings for electroplating equipment and small diameter electrical wire, coil impregnants and molded automotive parts, ladies' and children's footwear, molded heads, arms, legs and bodies for dolls, puppets, and novelties; and molded elastomeric industrial items such as seed tubes for farm machinery.

The rapid growth of molded plastisol articles naturally focuses attention on the techniques involved.

Plastisol molding differs markedly from conventional injection and compression molding, both as regards processing and end-use products. In general, these differences result in equipment economies and diversification of end-uses for molded plastisol products.



C. W. Patton

The diverse end-uses for molded plastisols to a considerable extent are closely related to the techniques involved in compounding and molding plastisols. In fact, some present end-uses for molded elastomeric vinyl compounds might well not be in existence were it not for certain processing possibilities that are inherent in plastisols. Thus, a clear picture of the plastisol processing technique is helpful in visualizing end-uses that can best utilize molded plastisol products.

Briefly, plastisol techniques are just about the exact opposite of conventional molding. For example, the conventional molding of elastomeric vinyl resin products proceeds essentially as follows:

A powdery or finely grained resin is **poured** out of a bag into a vessel; plasticizer is **poured** in with it and then the two are mixed with expenditure of considerable work and heat to insure the formation of a completely homogeneous mass, which upon cooling has the same properties as are desired in the end-product. However, it is still necessary to granulate, dice, or preform the compound to facilitate feeding it to the molding machine or press. In the press it is

necessary to apply heat and considerable pressure in order to get the compound to move into its final desired shape, in a rather sturdily constructed mold. In other words, two materials that could be fairly easily handled, which is the reason the word "poured" was stressed above, are deliberately converted into an extremely viscous mass which, although diced or granulated for intermediate handling, requires a lot of work to mold; all this in addition to the work expended in compounding.

PLASTISOL TECHNIQUE

The plastisol technique likewise starts with a powder and liquid but, by way of contrast, is carried on through in essentially the same manipulatable condition until the compound is in the mold where, by heat alone, it is homogenized, or fluxed, into its final physical condition as well as into its final shape.

A specially manufactured vinyl chloride type dispersion resin of microscopic ultimate particle size is dispersed in a plasticizer much as paint pigments are ground in oils. In fact, similar equipment can be employed.

The compounded plastisol, being "pourable," or at most a pasty material, can be poured into the mold, or sucked into the mold, or pumped into the mold with a gear pump or other relatively low-pressure feeding devices. If a hollow article is desired, and accurate control of wall thicknesses is not necessary, the excess plastisol can be poured out leaving only the material which clings to the mold interior. Since the pressures involved are negligible or non-existant, sturdy, massive molds are not required. Lightly constructed cast or electroformed molds are eminently suitable. The mold economies are obvious.

The plastisol with which the mold has been filled, or lined, is converted to an elastomeric compound by raising its temperature to about 350°F. Once the requisite temperature is attained, the conversion or fluxing is practically instantaneous. Upon cooling to around 140°F., the finished article may be removed. When the molded article is hollow, it is feasible to have deep undercuts, to use a one-piece mold and still readily remove the article by collapsing it with a suitable tool, twisting it into a knot, so to speak, and jerking it out. One-piece molds offer further economies, as well as absence of mold lines in the final product.

The fluxing process just referred to take place rapidly because the ultimate resin particles in a plastisol are at the most only a few microns in diameter, so are dissolved immediately by the heated plasticizer. Fortunately, most of the commonly used plasticizers exert very little dissolving action at normal temperatures so no special precautions are required to prevent premature fluxing.

While many of the advantages the plastisol technique offers molders are obvious, there are others less obvious.

For example, it was previously mentioned that the compounds could be prepared in paint grinding or mixing equipment. Partly as a result of this, a number of paint manufacturers, particularly those specializing in vinyl resin coatings, have taken to plastisol compounding like a duck takes to water. They have, in general, a wide range of colors, fillers, stabilizers and plasticizers available; also a considerable mass of data on the light, heat, and age-stability, and other properties, of various formulations on record. Paint manufacturers have a good background on development of various unique flow properties in materials. For instance, many brushing paints are developed with thixotropic properties which give the material an apparently high viscosity which prevents the paint flowing under its own weight when applied to vertical surfaces, yet at the same time the material is highly mobile when slight additional pressure is exerted on it. In some instances such properties are of value in plastisols used in "slush" molding because a more uniform deposition of material is left on the mold's interior when the excess plastisol is poured out. In other cases a high degree of fluidity is desired, particularly when a mold is to be filled rapidly, or when a plastisol is poured into a preheated mold and it is necessary to remove excess material rapidly.

Paint manufacturers, in general, have various grinding and mixing devices such as pebble mills which can be used in dry grinding resin to give a range of particle sizes for specialized flow properties in plastisols. A number have installed centrifugal or vacuum devices for deaerating plastisols, because air bubbles that may be worked into the plastisol during compounding or subsequent handling will, of course, cause voids in the finished product.

To sum up, in addition to having a basically simple technique to master, the plastisol molder immediately inherits the color-matching and other specialized techniques and services built up by paint manufacturers over a period of years.

FLUIDIZED

Since the plastisol technique is essentially a "fluidized" process, the production of highly plasticized rubbery end products does not present the normal granulation and hopper feeding problems. As a matter of fact, the more highly plasticized plastisols are exceptionally easy to handle because of their great fluidity. Conversely, by selection of proper particle size resin and blends of plasticizers it is possible to make pasty compounds containing 26% plasticizer which have a Durometer "A" hardness of around 100 after fluxing. It is also possible to increase hardness by loading the plastisol highly with fillers.

The relative fluidity of plastisols, as compared to conventional elastomeric molding compounds, simplifies color matching. It is possible to take standard colors and mix up a pint or a drum of material with simple stirring in which the various colors are added to produce the desired shade. Color problems are further simplified because the plastisol is exposed to high temperatures only during the relatively short fluxing period. Likewise, sponging or foaming agents, such as ammonium carbonate, can be mixed in and not be "gassed" prematurely by elevated temperatures as might be the case in conventional compounding.

The fluidity of plastisols makes it a simple matter to add materials such as luminescent pigments which would normally have their crystal structure damaged in high-pressure intensive compounding. Abrasive materials for step-pads and the like which would chew-up conventional compounding equipment can be simply stirred into a plastisol. The fluidity also makes it possible to use delicate mold inserts that might be damaged or deranged by conventional molding.

IN SITU MOLDS

Still further, it is possible to use internal molds, with no external part, simply by dipping the mold in plastisol, fluxing, and stripping the finished article off the mold or form. Various color effects can be obtained by multiple dipping in various colors. This dip-molding process has brought on a related technique where no mold, as such, is required. For want of a ready-made word, the technique has been dubbed "self-molding." (Possibly "in situ" molding would be a more elegant term.)

Items such as automotive light socket assemblies, which are normally protected by a molded cover or nipple that is slipped on after assembly, now have an individually-tailored, removable cover which is made by immersing the assembly the proper depth in a plastisol, removing, draining, and applying heat to flux the plastisol. Snug, dust-and-water resistant fits are obtained even though there may be slight variations or defects in the parts so covered. This technique not only eliminates mold cost but also eliminates the costs involved in removing forms from a mold, handling, and subsequent cost of putting the cover or nipple in place over the assembly.

In addition to the processing properties and possibilities, there is, as has been previously indicated, a wide range of physical properties obtainable with plastisols. An indication of how these properties vary is given by a comparsion of the properties of

a series of simple plastisols after fluxing—all containing 1% of stabilizer, dioctyl phthalate as the sole plasticizer, and varying in dispersion resin content from 50 to 57%. The Durometer "A" hardness goes up from 48 to 63. The tensile strength goes up from 1400 pounds per square inch to 1800 and conversely the percent elongation decreases from a figure of 380 to 350.

Special relationships between hardness and elongation, or speed of recovery, may be obtained by blends of plasticizers of different solubility characteristics. Plasticizers, such as the polyglycol derivatives, which may not have sufficient dissolving action to be used alone, may still be used in small amounts to increase the fluidity of the plastisol without much additional effect on the softness of the end product. In connection with plasticizers' effect on viscosities of plastisols, some recent experimental work is of interest. A number of plasticizers were made up into plastisols wherein the resin to plasticizer **volume** ratio was kept constant and their viscosities measured. These were then compared with the viscosities of the plasticizers alone. There was practically a straight-line relationship between the corresponding viscosities. This, and work on the ultimate particle size and structure of dispersion resin agglomerates, indicates that many of the flow properties of plastisols are simply a matter of geometry and physical properties rather than chemical interactions. This conception is of course altered when dealing with plasticizers which may react with themselves and undergo further polymerization in the fluxing operation.

There are many additional technical aspects in the formulation and application of plastisols, such as the selection of pigments, fillers, stabilizers, mold release agents, and bodying agents, but in summation the plastisol technique is basically a simple one; a mixture of small particles of resin suspended in a plasticizer is readily moved into position in a mold and there by heat alone "compounded" or fluxed into its final physical state and shape.

By using a number of low-cost molds on a conveyor or turret set-up, it is possible to obtain production rates that compare favorably with the out-put of an injection molding machine. By using only a few low-cost molds it is possible to write off mold cost even on comparatively small runs. This flexibility in processing, as well as the range of physical properties obtainable, makes plastisol molding a valuable adjunct for those now engaged in injection and compression molding. That it can be more than an adjunct is illustrated by the fact that plastisol molding has encouraged the entry, and been the basis for success, of newcomers to the molding fields.

Large Moldings Symposium—

Phenolics for Large Moldings

By Frank J. Donohue

Monsanto Chemical Co.
Springfield, Mass.

Very large moldings such as television cabinets bring special problems in materials properties, mold construction and product design. Remedies for some production difficulties are suggested.

Television cabinets are the big brothers of the radio cabinets of today and yesterday. They evolved in a series of steps. Like "children of a larger growth," they have presented on a larger scale many of the molding problems already encountered with their smaller brothers, the radio cabinets, plus some new and puzzling ones peculiar to themselves.

The most important of these problems have been: plastic flow, mold release, molded appearance, strength.

A. Flow

In order to mold a cabinet 18" wide, 20" high and 17" deep without using enormous molding pressures, the material must have special plastic flow properties. This is even more true when one undertakes to produce a cabinet such as the Admiral console, weighing approximately 42 pounds and measuring 34 inches by 18 inches. Long flow alone is not the answer. We have had long flow phenolics for years, but these were usually also slow flowing and slow curing materials.

What is needed in this case is a rapid flow material, which will complete its flow in minimum time and then set hard. You will appreciate the need for rapid flow when you realize that it is necessary to squeeze 16 to 35 pounds of material, that is becoming momentarily more viscous and infusible, up into four narrow spaces, 20" x 18" and only 3/16 to ¼ inch wide between the force plug and the cavity walls, in about 20 seconds.

Frank J. Donohue

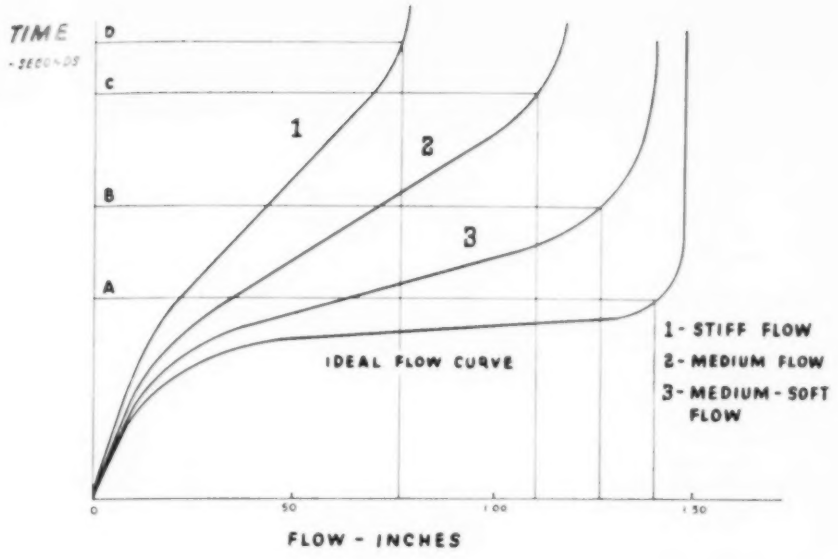
The need for rigidity of set is equally apparent, when you consider that a concentrated pressure of 20 to 40 tons is applied momentarily through the ejector pins on the ¼ inch wide edge of the piece at the beginning of ejection. If the piece is not extremely rigid, it will buckle, warp or break on discharge from the mold.

It was necessary to spend considerable research laboratory time, and many sweaty hours alongside presses, large and small before the right flow characteristics were developed.

In figure 1 are drawn some imaginary curves, illustrating the flow of thermosetting phenolic materials with respect to time. The "Ideal Flow Curve" shows the type of flow the molder desires and needs for present day large compression and transfer molds. The curve is quite flat, indicating extremely rapid flow. The flow time is measured by the vertical intercept, OA, from the origin to the point of inflection of the curve where flow has practically ceased.

This is the ideal toward which material suppliers have been working in recent years, in their efforts to supply the "softer and faster" material that has been the molders' dream for a long time past.

Curve #3 is characteristic of the type of flow that occurs in materials now furnished for molding of television cabinets. The flow time here, OB, is somewhat longer, the flow rate less rapid than for the ideal material, but markedly better than in



FLOW CHARACTERISTICS OF GENERAL PURPOSE PHENOLIC MATERIALS

Curves 1 and 2. These latter represent the flow-time characteristic of the usual stiff and medium flow general purpose materials. Here the flow time is longer but the total flow less than for the television cabinet material.

These flow curves, although based on actual experience and laboratory measurements, are considerably idealized. They illustrate, however, the faster flow rates needed on these newest applications. It should be emphasized, too, that smooth, uniform flow is required for best results. Any tendency of the material to squirt or surge unevenly at different points in the mold, leads to a variety of troubles, including color segregation, distortion of mottle pattern, where mottled materials are used, and porous or semi-filled, low density areas in the housing.

It is far from my intention to minimize the very effective role of electronic preheating in molding these large cabinets. This is vitally necessary and the introduction of newer, more efficient preheaters that heat large amounts of phenolic material rapidly has been an invaluable contribution to this whole program.

B. Mold Release

Once having molded this 20 to 40 pound cabinet, the molders next task, and sometimes a troublesome one, is to open the mold and get the piece out, without using sledgehammers or crowbars, or chilling the mold with ice water after every shot. Molders have an axiom that no part is too complicated to mold, but some parts can't be removed from the mold afterwards.

Television cabinets, because of their depth, and the large amount of surface area compared to the wall-section, present special problems of mold release. Adequate taper and well polished mold surfaces are a must in order to facilitate opening of the mold and ejection of the piece. I will leave to the molders any debate concerning the relative merits of converging and parallel tapers; I hesitate also to make any firm recommendation on minimum taper. I would suggest taking as much as the design and toierances will allow, and providing at least ½ degree, 0.0087 inches per inch of depth.

Even with sufficient taper, well-polished mold surfaces and a suitable material, a pull-back pressure of 40 tons may be required to open a big cabinet mold, particularly when it is new. If the material is not suitable, you may well lock the mold up tight. If you are a material service man and this happens to you while testing on a new mold, try to remain calm and think of some soothing comment to make when the molder stares at you wrathfully or reproachfully and says —"Well, what do we do now?"

We have found, as the result of a few such painful experiences, followed by a lot of head scratching and laboratory work, that good mold release on these jobs depends on proper lubricant content and good rigidity in the material, and above all, on using the proper flow for the job. A material that is too stiff, although it may fill the piece, is much more prone to jam the mold than one which is too soft, probably because excessive back-pressures and wedging forces are set up as the mold closes.

C. Molded Appearance

Lumped under this term are a number of phenomena such as color segregation, surface streaking, orange peel and sink marks, to name but a few. These may be due to material properties or to features of the cabinet design. They are equally troublesome in either case.

Many of the television cabinets so far produced have been molded from walnut or mahogany mottle colored phenolic materials, to simulate wood grain effects. In certain cases, to everyones' discomfiture, the cabinet instead of displaying the contrasting color striations or burled mottle effects desired, will show muddy areas where the component colors have blended together, or a "pepper and salt" effect where the color components show too little blending, and stand out in small discrete spots in the finished piece.

The blending into one muddy, composite color usually occurs when the material used is too soft, or the granulation of the components too fine. The condition is usually overcome by using material of stiffer plasticity and somewhat coarser granulation. Decreasing the preheat often helps by producing a slower, more uniform flow in the mold.

The pepper and salt effect is usually a function of the cabinet design and not readily eliminated by material changes. It shows up where flow of the material is slowed up or interrupted in passing around cores and pins in the mold which form louvre, tube and dial openings.

Abrupt contour changes at these points should be avoided in designing the cabinet. These openings must be provided, but transition curves, generous radii and rounded surfaces should be used as fully as possible to minimize these flow blocks. Location of the material charge in the mold is important, and frequently a change in the placing of the preforms when loading will eliminate or improve this condition.

Excessive orange peel or dogskin in the surface of the piece usually indicates insufficient back pressure, because the material is too soft, flows too rapidly, and escapes too readily when the mold closes. The remedy is to use a stiffer material.

Dull spots and streaks on the cabinet surface may result from a number of causes. One, which is less obvious and sometimes overlooked, is moisture which has condensed on the top electrode of the preheater and dropped on the preforms. Excessive preheating causes a somewhat similar effect. The remedies are self-evident, once the cause is recognized.

Most television cabinets contain interior ribs to provide mountings for the chassis and, in the case of the latest models, to hold the aerial which is fastened inside the cabinet. These ribs, particularly if they are of heavy cross-section, frequently cause sink marks or groove-like depressions on the opposite surface.

This is of minor importance in the case of the chassis mounting ribs which are usually on the bottom of the cabinet, where the sink marks are

out of sight. The other ribs, however, usually traverse the interior of the top or sidewalls, where the sink marks are plainly visible and very objectionable, particularly if accompanied by discoloration and distortion of the mottle pattern.

The fundamental cause of this difficulty, and its solution lie in the cabinet design. To avoid sink marks on the surface, the width of the rib, at the root or point where it joins the wall, should be no greater than the adjacent wall section; the height should be kept to a minimum, preferably not greater than twice the wall section.

Where some other design consideration prevents this, the sink mark may usually be masked by a decorative bead or flute on the outside surface over the rib.

If this stratagem cannot be used, either because it interferes with some other design feature, or violates the designers aesthetic sense, the only other remedy so far found is to reduce the mold temperature and the amount of preheat, thus slowing down the flow of the material and reducing the differential shrinkage at the critical section.

Unfortunately, this is frequently only a partial remedy. It may decrease but not wholly eliminate the objectionable sink mark. On the other hand, it will almost certainly increase the cure time, cut down production from the mold and therefore wring anguished cries from the molder and set manufacturer. In this case, certainly, preventive rather than corrective medicine is more desirable.

D. Strength

The problem of providing sufficient strength in a television cabinet should be no more difficult than in a smaller housing. It is, however, more important for a number of reasons:

1. A television set is a higher priced home appliance and the usual purchaser expects full value for his outlay, including a cabinet that will withstand all reasonable normal usage.

2. Some of the circuits in television sets operate at potentials of 12,000 to 18,000 volts. Breakage of the cabinet might expose the user to a dangerous shock hazard. This possibility should certainly be guarded against in the cabinet design.

3. Television assemblies are considerably heavier than radio sets. There is greater danger of cabinet breakage during final assembly due to improper handling.

Proper strength in these cabinet is not a matter of luck or guesswork; it can be provided by following correct design practice—adequate and uniform wall sections and proper use of fillets and radii, to avoid local stress concentrations.

Large Moldings Symposium—

Styrene in Large Moldings

By Sanford E. Glick

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The suitability of styrene for large moldings is becoming more evident and attractive. Its applications in refrigeration and other fields are on the rise.

A. Dimensional Stability

One of the first requirements for large moldings is dimensional stability. Any changes in dimensions in the large industrial pieces would obviate the use of plastics on such jobs.

There are many factors which contribute to dimensional stability of plastic materials. Since plastics are generally organic compounds, one must be prepared to accept a certain degree of instability not usually encountered with metals. The measurement of dimensional stability is, therefore, of prime importance to the designer and user of plastics, since such data provide a basis for design adjustment which frequently is the difference between success and failure. This is particularly pertinent to large moldings. What is meant by dimensional stability? We find that dimensional stability can be classified under numerous headings and is a function of one and all of the following:

1. Zero stress dimensional stability —What effect do humidity, drying, and cycling have when no load is applied?
2. Heat Distortion Temperature
3. Cold Flow
4. Effect of temperature on physical properties
5. Water absorption

Sanford E. Glick

6. Volatilization of components such as plasticizers.
7. Presence of internal strain.

Inherently stable plastics can be defined as those which are not affected by atmospheric influences such as heat, moisture, combinations thereof encountered in normal engineering use.

1A. Zero Stress Dimension Stability

In selecting a plastic for an engineering application, its dimensional stability when no stress is applied is of prime importance. This property explains the advantage of using styrene plastics in such applications as containers, housings, refrigeration parts, and other components of large projected area, where no warpage can be tolerated. However, the importance of operating temperatures should not be overlooked. Thermoplastic materials will distort when excessive temperatures are reached.

2A. Heat Distortion Temperature, Water Absorption, Flammability

Data on water absorption and inflammability, as indicated by Table 1 are also of prime importance in selecting materials for engineering applications, especially in large moldings.

The maximum operating temperature of molded thermoplastic parts depends upon the design of the piece, sustained load and the presence of strain in the molded piece.

Industrial products molded of styrene such as radio cabinets, camera cases, automotive parts and electrical components have been known to withstand intermittent temperatures as high as 200°F without distortion, if the molded pieces are relatively free of strain and the proper heat resistant formulation of styrene is used. The usual maximum safe operating temperature for general purpose styrene molded parts is 170°F; but even

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TABLE 1

Material	Water Absorption -%	Heat Distortion Temp. -°F.	Ignition Temp. -°F. With Flame	Ignition Temp. -°F. Without Flame
Styrene-General Purpose	0.04	175-190	653	910
Styrene-Heat Resistant	0.04	203-235	653	910
Cellulosics	1.1 -5.9	115-220	580	842
Acrylics	0.05	150-210	574	860
Vinyls	0.07-0.08	142-153	680	1112
Phenolic-Paper Laminate	2 -5	———	644	968
Melamines	0.1 -1.3	———	898	1130
Cellulose Nitrate	1 -2	140-160	291	291

170°F may be too high for parts containing large stresses.

3A. Cold Flow

Another important requirement in large moldings is freedom from cold flow. A practical definition of cold flow is a change of dimension caused by sustained application of a load that stresses the material beyond the elastic limit at a temperature below the heat distortion point.

A test of cold flow is to measure the percent change in thickness of a ½" cube placed between parallel plates under a constant pressure of 4,000 psi at 120°F for 24 hours. Table 2 based on the results of scattered investigations gives a rough comparison of cold flow of various plastics. A heat resistant styrene formulation has about ⅔ the cold flow of a Grade L phenolic laminate, under the stated conditions.

TABLE 2

Material	Cold Flow
Heat Resistant Styrene	0.35- 0.40
General Purpose Styrene	0.6 - 0.8
Phenol-Formaldehyde	0.4
Urea-Formaldehyde	0.4 - 7.0
Polyvinyl Chloride	1.0 -32.0
Cellulose Acetate	2.0 -64.0
Cast Phenol Formaldehyde	10.0
Hard Rubber	0.5 -80.0

4A. Effects of Temperature

Another important consideration for the use of plastics especially on large military applications, is the effect of temperature on physical properties. Most plastic materials become increasingly brittle at lower temperatures. The physical properties of styrene actually improve as the temperature is reduced. This also applies to the acrylic plastics. In going from room temperature to zero degrees Fahrenheit, there is an improvement in tensile strength of 30 percent, in elongation of 20 percent, flexural strength of 30 percent, deflection of 40 percent, and impact strength of 20 percent. This characteristic is responsible for the wide acceptance of styrene and acrylics in automotive and refrigeration applications and should also be of use in military items.

5A. Miscellaneous Dimensional Stability Considerations

Still other factors which contribute toward the dimensional stability are freedom from volatilization of components such as plasticizers and also freedom from polymerization or curing after molding. Both of these factors account for shrinkage with age. Since styrene and acrylics contain no plasticizers and no polymerization after molding occurs, dimensions of a molded part will be maintained indefinitely if kept below the heat distortion temperature. Also, there is no deterioration in properties due to aging for inside applications. It is important for the designer and molder to know that once the pieces are molded, no further changes in dimensions will result.

B. Strength Specific Gravity Cost Ratio

Still another practical factor to be considered on large moldings is the ratio of physical strength to specific gravity to cost. It is this ratio which often dictates the use of a given material on any job. From Table 3 it can be seen that wood ranks first. Nevertheless, a number of the thermoplastic materials such as styrene and cellulose aceto butyrate also rank well up in the scale. In fact, their positions are well above the normally accepted materials of construction such as aluminum, plywood, and bronze.

APPLICATIONS

Because of these properties, the more dimensionally stable plastics are finding increasing use in large moldings in such fields as refrigeration, radio and television, wall tile, automotive, packaging, lighting fixtures, electrical, and display signs. Of the total styrene used in 1950 it is estimated that approximately 35-40 percent went into industrial applications. Furthermore, it is anticipated that the major growth in styrene within the next five years will be in industrial applications. By 1954, it is believed that 45-50 percent of all the styrene used will be in industrial applications.

A. REFRIGERATION

One of the largest single users of plastics is the refrigeration industry. During 1949, almost 5,000,000 domestic refrigerators had built into them more than 80,000,000 pounds of plastic. For 1950 the estimated consump-

TABLE 3
RATIOS OF PHYSICAL STRENGTHS OF MATERIALS OF CONSTRUCTION AND CERTAIN PLASTICS TO SPECIFIC GRAVITIES AND COST

Material	Flexural Strength	Tensile Strength	Specific Gravity	Cost	Flexural Strength Sp. Gr.	Flex. Str.: Sp. Gr.: Cost	Relative Order, Flex. Str.: Sp. Gr.: Cost
	p.s.i.	p.s.i.		$/lb.			
Wood—yellow pine	12,700	16,000	0.63	0.02	20,200	1,010,000	(1)
Glass	13,000	9,500	2.60	0.80	5,000	62,400	(2)
Hard rubber	12,000	7,000	1.30	0.19	9,200	48,400	(3)
Styrene—colored	10,000	7,000	1.06	0.315	9,400	30,000	(4)
Phenolic plastics-avg.	10,000	7,500	1.38	0.25	7,200	28,800	(5)
Cellulose acetate butyrate	7,500	5,000	1.28	0.52	14,400	27,700	(6)
Aluminum	12,000	22,000	2.70	0.16	4,400	27,500	(7)
Concrete (1:3:3)	500	200	2.31	0.009	220	24,500	(8)
Plywood (⅜ in.)	8,000	9,600	0.68	0.09	11,800	17,400	(9)
Cellulose acetate mld. pwdr.	8,000	6,700	1.32	0.40	6,100	15,200	(10)
Structural steel-0.3% carbon	33,000	85,000	7.85	0.033	4,200	12,600	(11)
Copper	15,000	47,000	8.89	0.16	1,700	10,600	(12)
Nylon	14,600	50,000	1.14	1.60	12,800	8,000	(13)
Methyl methacrylate	7,000	5,000	1.18	0.80	5,900	7,400	(14)
Phosphor bronze	12,000	120,000	8.81	0.345	1,400	4,100	(15)
Lead	1,852	2,700	11.34	0.12	160	1,300	(16)

tion is for even greater amounts. (8,000,000 refrigerators and 140,000,000 pounds). In this field, large injection molded items first appeared to an extensive degree.

Sound economic and practical engineering considerations dictate the ever increasing trend toward plastic applications in refrigeration. Of the many materials which plastics are replacing are the following; hard maple, metal, porcelain enameled sheet steel, glass, aluminum, rubber, die castings, and plated metal stampings. A consequence of this replacement has been better refrigerators with more storage space, lower operating costs, longer life, and less maintenance. It has definitely been established that plastics serve as more efficient materials in those instances where they have replaced the materials mentioned above. Another corollary to the growth of plastics in refrigeration has been the effect which the refrigerator manufacturers have had on the technical and market development of the plastics industry. By their enthusiasm for laminated plastics door liners, they have helped foster an improved laminate. Also, partly through the demand for larger thermoplastic molding machines came the result of bigger presses, improved mold making and better molding techniques. In one of the 1948 Crosley refrigerator models, 97.5% by weight of the plastics used are for structural and functional applications, while the remaining 2.5% goes into parts used solely for decorative purposes. In this particular model, the use of styrene and laminated phenolics is practically equal on a weight basis, each type of material accounting for approximately 49% of the total. The balance of 2% was made up of acrylic, urea, phenolic, and cellulose acetate. As a further comparison, the total plastics weight of 18.28 pounds was 5.54% of the total refrigerator weight.

One of the Crosley 1950 refrigerators employes 58 different plastics parts. In this particular model, a total of 24.135 pounds of plastics are used, of which 17.546 pounds are styrene. Since the largest refrigerator manufactured by Crosley in 1941 used plastics in only a minor role, it can be seen just what trend has developed in the refrigeration industry.

Plastics have replaced glass on such parts as meat storage trays. Glass suffers from such disadvantages as excessive weight, high breakage, low resistance to thermal shock, and susceptability to chipping, with the possibility of glass slivers entering the stored meats or other food. Also, it was found that breakage during shipment on glass trays ran very high. In contrast, breakage on styrene trays has run less than 0.2%.

Plastics are particularly good from the standpoint of heat conductivity, and hence may be used where a thermo-break is required. Furthermore, the possibilities inherent in large molded pieces enabled the refrigerator maker to eliminate certain assembly work by replacing as many as four or five parts in a previous assembly with a single piece of molded plastic. So too, plastics have unlimited decorative possibilities.

ADVANTAGES

As far as replacing stamped, enameled metal with plastics is concerned, there are distinct advantages. The plastic pieces have the advantage of light weight, freedom from odor and taste, resistance to chemical and moisture attack, warmth to the touch, and surface and color permanence. Also, injection molded pieces have definite design advantages in that they can be snapped into position easily in a fraction of the assembly time required for metal components. Enameled metal refrigerator parts also suffer from the disadvantage of chipping and allowing food particles to accumulate in the crevices and cracks. Such an accumulation eventually leads to distinct food odors. Since colored plastic parts have color permeating the entire mass, there is no possibility of lacquer chipping off and presenting the same difficulties. From an economy viewpoint, plastics are also of interest. On some plastic parts, it is estimated that some of the pieces would cost at least ⅓ more in anodized aluminum. The cost of porcelainized sheet metal would also be considerably higher than similar parts molded from plastics.

With respect to wood, plastics exhibit distinct advantages in reduced moisture absorption, and improved dimensional stability. Furthermore, simplicity of fabrication and assembly operation as well as elimination of lacquering are other reasons for using plastic to replace wood on breaker strips.

Rubber has been replaced in a number of instances in refrigeration by such plastics as phenolics, urea and styrene due to lower cost, wider color possibilities, and dimensional stability.

CABINETS

Another trend in refrigeration is the use of styrene for ice-cream cabinet lids. Large moldings up to 500 inches in projected area and weighing 2½ pounds have been produced. Originally such parts were made from a molded hard rubber frame, aluminum bottom, and stainless steel top. The superior performance of the plastic lids stems from the fact that it has less tendency to sweat in humid weather than the old lid, due to its lower conductivity. Furthermore, it is essentially lighter in weight, costs less and has improved efficiency. Styrene also lends itself to a much more attractive appearance, inasmuch as it can be molded to contours difficult or impossible to achieve with materials formerly used. The unlimited color range of styrene also provides a distinct advantage over the dark shade formerly available with rubber. In conjunction with styrene for use in ice-cream cabinet lids there now are employed slabs of foamed styrene for insulation as well as elastomeric vinyl materials for gaskets.

The recent advances in the use of plastic in refrigeration by no means represents the final goal. With the availability of larger molding equipment, consideration now is being given to molding plastic food liners with integral panels. Similarly, a molded outer door and shell holds real interest. Possibly such items can be made through injection molding. An inner door panel with a projected area of over 1,000 square inches and weighing 6 pounds has already been molded on an experimental basis.

It should be realized that the use of plastics for such large parts would greatly improve the efficiency of refrigerators. A 7 cu. ft. refrigerator generally has 7, 8 or maybe 9 cu. ft. of insulation in the walls. A 7 cu. ft. refrigerator would perhaps be a 15 cu. ft. refrigerator if insulation only 1/16 inch thick could be used. Consequently any trend from metals to plastics would insure better use of available space in refrigerators.

Although the concept of an all plastic refrigerator may at the moment seem over optimistic, nevertheless, continued steps towards utilizing the full advantages of plastics materials would contribute toward better refrigerators. Certainly the experience of the last 10 years points the way toward ever increasing use of plastics in refrigeration.

B. RADIO AND TELEVISION

Another field which employs large injection molding is that of radio and television. Although the compression molding field has been the leader in producing large parts for radio and television cabinets (parts weighing up to 42 lbs. each), nevertheless there are a number of parts currently being injection molded which are also of large proportions. A number of colorful possibilities have been exploited in the radio cabinet field with injection molded styrene parts.

As for television, we find that most of the lenses currently being used in television sets are of injection molded styrene. Lenses for the 19" tubes are currently in production. Also, a number of television masks of various sizes have been satisfactorily injection molded. The weight of each part goes as high as 3 lbs.

At present there are no injection molded television cabinets. However, one large manufacturer is investigating the possibility of producing thermoplastic television cabinets. Naturally the main problem to be overcome is reduction in temperature buildup

durite operation of the set. With some of the injection molding equipment currently available, it should be possible to injection mold cabinets weighing up to 20 lbs.

In the radio and television field, thermoplastics have replaced glass, wood, and metal, mainly because of lower cost, better dimensional stability, and ease of manufacture. In certain instances, the improved electrical properties have also played a part.

C. AUTOMOTIVE

Cellulose aceto butyrate has played an important role in the production of steering wheels. In 1949 Nash employed 4 pounds of styrene in the dash board. Numerous acrylic parts also find their way into the automotive field. Again, the engineering, low cost, and ease of fabrication properties of the thermoplastic materials are instrumental in their choice.

D. AIRCRAFT

One of the largest injection molded items to date is being employed in jet planes, a battery case which weighs 11 lbs. One molder produces this in one shot whereas another molder produces it in two pieces and cements the parts together. The styrene battery case is lighter in weight and requires less space than other non-spill, lead, acid and rubber batteries. In addition to this battery, a number of other batteries are being produced for the communication field. Batteries cases weighing 3 lbs. are currently being molded for Western Electric.

E. MISCELLANEOUS

There have been other cases where large injection molded parts have been used to advantage. A circulating floor fan is illustrative. With injection molded parts, improved dimensional stability, a reduction in weight of 17 to 25%, adequate insulation for safe and efficient operation, manufacturing economies, and resistance to moisture are obtained. The top piece of the fan has a projected area of 225 sq. in.

Still another example of large injection molded parts is that of a cellulose acetate military item weighing 14 lbs. To our knowledge, this is the largest injection molded piece to date.

Drawing instruments which require close dimensional tolerances are also representative of engineering applications for thermoplastics. Here we find styrene, acrylics and some of the more recent styrene copolymers being used to a wide extent.

The thermal insulation properties of styrene are also used to good advantage in thermosbottles.

Still another field using large moldings is the lighting fixture field. Not only are thermoplastics such as styrene and the acrylics being used for indoor lamp globes, but we also find that some street lamp bulbs with thermoplastic parts have given superior performance. Again, the inherent properties of the thermoplastic materials are responsible for their use.

Another striking application of styrene is in the display field.

IV. MILITARY APPLICATIONS

With the recent mobilization program rolling into high gear, interest is now directed toward adapting plastics for military applications. Past experience indicates that plastics have served useful functions. In the case of the Signal Corps flashlight housing it was found that the plastic was the most foolproof part of the assembly. The metal components caused the most trouble due to corrosion and leakage at the joints.

Molders should direct their efforts toward using plastics whenever possible. Many military items which are currently being die cast out of zinc-aluminum alloys could be very easily produced by injection molding. Marked savings in cost, in some instances amounting to 50%, as well as other advantages in productivity could be effected. The impending shortages in die casting materials should act as an incentive in replacing these critical materials with plastics. One such attempt has already been made in replacing a zinc alloy dummy nose plug for 40 mm anti-aircraft projectiles with plastics.

The military requirements should also prove a fruitful field for large injection moldings. Such items as foot lockers, bread boxes, containers and housings for various items such as typewriters can now be molded on the existing large injection molding machines.

Polyesters

By Earle S. Ebers

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The versatile polyesters have a great range of applications in moldings, laminates and pottings.

HISTORICAL INTRODUCTION

In 1901 a very significant happening was recorded when Watson Smith reported obtaining a resin-like substance upon heating glycerin and phthalic anhydride together.

This fact may have activated the research laboratories of the General Electric Company or it may not; however, in 1910 they began a study of these glycerin, phthalic anhydride resinous bodies. Their researches culminated in 1916 in the commercialization of the resins as surface coatings.

Concurrent with the General Electric researches, studies by Messrs. Gibbs and Conover of the U. S. Department of Agriculture had perfected a direct oxidation process for phthalic anhydride from naphthalene.

Earle S. Ebers

This development brought the price of phthallic anhydride down from $2.85 per pound in 1916 to 46c in 1920 and 13c in 1930.

It did not take long for the outstanding qualities of polyesters as quick drying durable finishes for woods and metals to become recognized and the usage of these materials grew from 138,000 pounds per year in 1917 to over 138,000,000 pounds per year in 1944.

During this period of expanding usage many variations were introduced, among which were resins containing maleic, an unsaturated anhydride, for all or part of the phthalic anhydride. In addition, other outlets than surface coatings were being constantly sought and these resins had

been tried as binders and impregnants similarly to the phenolics. Their rate of cure was so slow however that despite their good aging and electrical qualities they did not receive commercial approval for this type of usage.

The discovery of C. Ellis in 1937 that the addition of unsaturated monomers to these resins would increase their speed of setting by 30 fold or more was highly significant since it brought the excellent properties of the alkyds into the commercial curing range of binders and saturants for fibrous fillers such as glass, cotton, sisal, paper, leather and synthetic fibres.

Polyester Sheet is Tough and Transparent

Time went by and a new very reactive ester was developed from allyl alcohol. This allyl diglycol carbonate was introduced in 1942 in cast form as a glazing material for aircraft. Its advantages as a binding material for aircraft laminates were quickly recognized and the demand for it soon outran the supply so that alternate materials were sought. Resin suppliers then remembered the experimental discovery of Ellis and it was taken from the research shelf and impressed into commercial service.

Thus in 1942 polyesters as we now generally know them were born and a new class of thermosetting resins of the following properties was available.

Good aging
100% reactivity
Rapid curing without porosity
Wide viscosity range
Good chemical resistance
Good electrical properties
Good abrasion resistance
Wide color range

Good temperature shock resistance from -80°F to 212°F and in combination with fibrous fillers such as nylon, cotton, sisal, rayon, paper and in particular glass the above properties plus

High specific tensile and flexural strength
High impact resistance.

WAR USES

The handling properties of low viscosity, 100% reactivity and rapid curing without porosity under none or a minimum pressure permitted that American production ideal of continuous operation in the lamination of glass cloth and large quantities of sheet stock of this nature were made. These were used as support panels for self sealing gasoline tanks in aircraft.

More complex aircraft structures such as air scoops, water and de-icer tanks, wheel farings and ducts quickly followed as experience with these versatile polyester resins grew because they gave

Weight savings
Elimination of costly tooling
Man and machine hour savings
Versatility

The excellent physical and dielectric characteristics of these laminates were utilized in radomes.

WAR DEVELOPMENTS

Experimentation on structural sections such as the BT-15 airplane fuselage by the AAF Material Command Wright Field clearly demonstrated that polyester fibre glass laminates compared to metals and in particular 24 ST aluminum have

Higher specific strengths
Greater damping capacity
Better thermal insulating properties
Better acoustical insulating properties
Possible fabrication advantages in time savings and simplified structures.
Greater adaptability to variable gauge sections.

These advantages were further borne out when the construction of the Sikorsky Aircraft R-6 Helicopter cabin was changed from metal to plastic with

Over 10% saving in weight
Greatly reduced noise level

A reduction in parts to assemble from several hundred to only 26.

Approximately a 50% reduction in production time.

Simple boat structures were a natural and appeared early on the scene.

A great development saga had been written and enthusiasm was rampant for the post-war possibilities of this Cinderella when the war came to a close and the fairy godmother was gone.

POST-WAR

In 1946 with only a fraction of the market (estimated at around 6,000,000 pounds of resin at its peak) they enjoyed in 1944 and 1945 the resin and glass suppliers, design engineers and the fabricators put their faith in these new materials to work to demonstrate that in war or peace time this was a major discovery of unlimited potentiality.

New product ideas were developed, resin uniformity and quality were improved and engineering ingenuity was applied to yield better techniques and equipment as knowledge of the characteristics and handling properties of these materials expanded.

More specifically, polyester resin sales rose from perhaps 1,500,000 pounds in 1946 to 7-8,000,000 pounds in 1950 and these resins were used in the following amazing variety of products.

Continuous Laminations:

This was the first and simplest conversion; two polyester bonded glass cloth products found peace time usage as cargo liner and photo template. Immediate introduction of a paper laminate into the wall board and decorative table top field also helped to absorb some of the capacity of these machines. All these products have survived and appear in a healthy state today because of improvements in resins and processing techniques.

Cast Sheet and Tubing:

Abrasion resistance and good optical clarity are utilized for glazings, while the excellent electrical characteristics of these resins lead to parts for electronic and radar equipment. Further, they replace more expensive amber in x-ray equipment.

Fishing Rods:

By applying the very high strength to weight ratio of polyester bonded parallel glass fibers to rod making in analogy with the natural bamboo product this new fisherman's delight was born.

Boats:

This application was a logical extension of the armed services experimentation in this field and with new techniques commercial boats of more versatiie design are being built with 45 to 90% savings in man hours. Other pluses are lighter weight, salt water resistance, imperviousness to rot and worms, no annual caulking and high impact resistance.

Luggage and Carrying Cases:

The abrasion resistance, high strength properties, light weight and integral color lend themselves to attractive carrying cases for musical instruments and luggage.

Caskets:

The smaller sizes have been profitably made where ease of fabrication is a primary factor along with good strength and rot resistance.

Prosthetic Devices:

Artificial limbs and foot supports when tailored to fit must be readily fabricated, have high strength, dimensional stability, and good chemical resistance to body acids.

Automotive:

Light weight, ease and economy of repairs are the main advantages. Competitive costs have only been obtained to date in cases such as trailer fenders and electric cruising car bodies where the total of pieces required was small.

Sealant for Porous Castings:

Excellent against petroleum products and thermal shock.

Lamp Shades:

High light transmission permits lower wattage bulbs. Easy cleaning, strength and resistance to heat and moisture are other features.

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Outdoor Signs:
Good weathering, toughness, lightweight and integral color contribute to low maintenance costs.

Street Lamp Globes and Reflectors:
Toughness towards sharp stones, good light reflectance, and good weather resistance make this a highly practical application.

Trumpet Mutes:
This is a typical example of the hollow articles which might be made in a single piece having no joints to develop weakness under continuous vibration.

Project Tools:
Polyester glass laminate project tools in the aircraft industry give large time and money savings over metal tools and do a better job being less liable to distortion and damage in service.

Large Pieces:
That size is no limitation to polyester glass laminate structures is evidenced by the 650 pound synchroton piece and the 700 pound Westinghouse photometer sphere made from them. High strength, good dimensional stability, excellent electrical properties and weight savings are additional features.

Minnow Bucket:
Another fisherman's aid having light weight, long life, integral color and freedom from rusting.

Moldings:
The fast curing of polyesters has given molding compounds for the electrical industry with very high tracking resistance and 30-90% greater productivity. Other special formulations give rapid production of television antenna holders and tough colorful battery boxes.

Mannequins:
Ready formability, and toughness to withstand window temperature extremes and frequent handling are qualities necessary here.

Washing Machines:
Substitution of light weight, integral color, strong, non-corrosive polyester glass fibre laminates gives lower production costs via shorter assembly times and fewer parts.

Laminates for Electrical Uses:
High arcing resistance and low moisture absorption combined with high flexural and impact strengths make these excellent for commutator blanks, monorail insulators and other electrical applications.

Furniture:
The dream of a light weight, rugged, warm feeling, good weathering, integral color material for home and industrial furnishings appears to be solved with polyester laminates.

Boxes and Carrying Cases:
Strong, lightweight, washable, nonrusting and dimensionally stable industrial boxes are being made for carrying bread, meat, mushrooms, textiles and other materials which must have careful handling.

Industrial Housings:
Lighter, stronger and more corrosion resistant than metals, with better sound absorbent and impact properties these polyester glass laminates also cost less because of lower assembly and finishing costs.

Chemical Piping:
Corrosion resistance combined with lightweight and relatively high bursting strength even at temperatures up to 425° F are featured.

Structural Laminates:
As a new building material polyester glass fibre laminates are offering durableness, dimensional stability, lightweight with greater strength, weatherproofness, and low maintenance. Windows, skylights, patio roofs and interior panelling are suggested usages.

Pottings:
Decorative figures, biological specimens, and electrical setups can be readily protected even at elevated temperatures by encasing them in polyesters and this has been done extensively with electrical parts because of the low moisture absorption, and good electrical characteristics of these resins.

FUTURE

Two major factors appear to govern the future expansion of a product and they are first its ability to yield more productivity per man hour than current materials and second its ability to appear in a maximum number of desirable forms.

Man Hour Productivity:
This factor breaks down into the sum of

(a) Man hours to produce and deliver raw materials to fabricator.

(b) Man hours to fabricate end article and

(c) Man hours to maintain end article divided by the useful life of the article.

Now comparative to the technology of woods and some metals the chemist and engineer have hardly turned the first pages in their thinking on polyesters and polyester fibre combinations and if, as established in the 1946-1950 period, these are already competitive in many cases can there be doubt as to their future potentialities? For example—those next pages already show

Resins of greatly improved heat resistance

Possible new glass pretreatments for improved strength

New film transfer and slush molding techniques

New associations of currently known facts.

This latter factor may be better understood if one considers a specific problem such as the casting of a dumbbell shape. Here the immediate reaction is that resin shrinkage during cure will tear the dumbbell apart and the piece appears impossible in solid molds until it is recalled that the thermal coefficient of expansion of these resins is greater than that of metals and although the pieces will not fit at room temperature they will readily fit at some higher temperature. New trials are made and successful production of a simple restricted shape attained, opening whole new horizons.

Versatility:
Structures from buttons to atom smashers, flat sheet to B-29 duct work, and work trays to radomes, attest to the handling and physical properties versatility of these materials.

In conclusion it is suggested that application of your creative imagination and ingenuity to these materials will yield high rewards similar to those attained by the dreamers of 1944 and 1945, a large percentage of whose ideas are now commercial realties.

Table 4 of George Blum's paper appearing on page 8 of the January issue of the SPE Journal should have been credited to J. H. Parliman of Plax Corporation, whose data originally appeared in his article "Polyethylene Permeability" in Modern Packaging for July 1948. The oversight was unintentional.

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Underwriters Laboratories Viewpoint On the Use of Plastics

By Karl S. Geiges
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The Underwriter's Laboratories are interested in specific applications of plastics only insofar as safety of person and property might be involved. Their tests and approvals are geared to safety in use.

In making a clear and concise statement of the viewpoint of Underwriters' Laboratories toward the use of plastic materials it should be clearly understood at the outset that the sole basis for having a viewpoint or opinion at all is that the application is one in which safety of life and property from fire and accident hazards are involved. If they are not then the Laboratories has no concern with the kinds of materials used.

Underwriters' Laboratories is a non-profit testing organization with three testing stations located at Chicago, New York and San Francisco. Over 200 graduate engineers examine and test equipment intended for use in home, office and factory to determine whether it is safe from the standpoint of fire and accident hazards. Favorable opinions, so arrived at, are published for the information of insurance and government inspection authorities on a country-wide basis. An essential part of the activity is the continuing follow-up on production at the manufacturing plants by resident inspectors who are empolyed by Underwriters' Laboratories.

As mentioned previously, opinion as to safety is the sole end of the work that is done. These opinions are not those of individuals working independently, but are based on over fifty years of experience in fire protection and related engineering work. Where there is sufficient interest in a specific product the requirements that have been established are made available to industry in the form of standards which are sent out to manufacturers and other interested activities for comment before being published. Every effort is made to obtain all available factual data, both practical and theoretical, before requirements are established and some of the best known research centers in the nation both public and private have assisted in this endeavor.

Back in the twenties when phenol formaldehyde and vulcanized fibre were the most common forms of electrical insulation manufacturers of these materials submitted their products for investigation and listing. The tests were designed to determine dielectric strength, moisture absorption, effect of common acids, bases and salts, combustibility and mechanical strength. The problem of identifying the material when it was found in

Karl S. Geiges

the end product was never completely solved and became more difficult with the constant increase in the variety of compounds.

Finally during the thirties it was decided that listings of electrical insulating materials had little practical value and they were discontinued for all manufacturers although we continued to maintain the data in our files and to test new materials where conditions justified such work. Most materials continue to be tested in connection with the end product use wherever the properties of the material leave any doubt as to acceptability of the assembly.

In the late thirties thermoplastic materials began to appear in the construction of electrical equipment and they were handled on an individual basis as outlined above. During World War II some additional uses of thermoplastics were adopted on a sort of trial basis after thorough consideration of the available data and in view of material shortages that were of an emergency nature. Then after the war large capacity for plastic materials became available for peacetime production and it was evident that in the interests of uniformity some general decisions on the application of such materials in the electrical equipment field were necessary. A meeting of plastic materials manufacturers was arranged and the problem was discussed in detail. There was no basic objection to the proposal that where safety was involved the acceptance of thermoplastic materials would not be extended to devices intended for permanent wiring. However, we agreed that in the case of portable appliances, where the greatest interest had been indicated, we would proceed on the basis of individual appliance test performance. Today we have more laboratory data and field experience than was available when the decision was made and some of the field data gives definite indication that the past procedure has been sound.

In discussing the present viewpoint in more detail there are four general groups into which we can divide the subject so as to provide a clear understanding of the problem:

Wires:

First, there is the group of plastic materials employed in wire insulation. Wire insulation has always been considered as a completely separate application and not one that should be used as a basis for parallel action in the field of rigid material applications. Certain concessions to the need for flexibility in a cable wire or cord have been made with the knowledge that this part of the wiring system involves inherent weaknesses that cannot be overcome by means feasible with a rigid assembly. For example, rubber has long been recognized as a wire insulation even though it is combustible and subject to deterioration through aging. On the other hand, rubber is rarely used in the insulation of fixed parts of electrical devices.

In the wire field polyvinyl chloride was introduced as a substitute for rubber insulation in the late thirties. The aging and combustibility of the basic material was greatly superior to rubber, but the tendency to cold flow was a matter of great concern. Improved compounds and manufacturing techniques have brought this material into general use for building wires and flexible cords so that no detailed discussion is required for those materials. There is some interest in the recognition of all thermoplastic nonmetallic-sheathed cable, a product new in this country although used in Europe for some years. In that case it was felt that a new material intended to replace an existing material which had a satisfactory performance record should not introduce a hazard through its tendency to flow at elevated temperatures caused by abnormal current in the cable. Even though the aging, flame and insula-

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tion characteristics of the new material were superior it was felt that they could not balance cable failure at current values that might occur in service under extreme adverse conditions, and a suitable compound change was made. This weighing of all factors in performance of a plastic material against existing knowledge and experience with other materials is part of the procedure in arriving at the viewpoint we are discussing.

WIRING

Also in the wire field is the item of appliance wiring material with its higher temperature ratings and tendency toward lesser wall thickness. The new plastic compounds have taken us from 80 C to 90 C then to 105 C and there is talk of 125 C wire. Each increase in temperature is investigated and in some cases the requirements are more severe than the temperature increase would appear to require. For example, we require what has become known as the "hot chisel" test on the higher temperature wires when it is known that the 80 C wire will not meet that test. Actually the experience with wires operating up to 80 C is extensive whereas the 105 C area is largely one of anticipation, hence this new test tool which attempts to evaluate performance at the new level with an approximation of a severe service condition.

The use of nylon magnet wire as Class B insulation is an example of a problem of the moment which calls for somewhat different handling. We do not list magnet wires, but follow the temperature limits given in AIEE Standard No.1. No data on the effect of aging at Class B temperature levels has been made available as yet and we would hesitate to make such an investigation because of the time required to obtain results. In our opinion data from sources that have already investigated this use should be provided so that a relatively simple test could be made to check the device performance.

Housing:

In general the housings for electrical apparatus are decorative, functional or both. Those of a purely decorative nature are not of concern to UL engineers unless they happen to be of a highly combustible material thereby introducing additional fire hazard. The functional housing generally encloses live parts and is tested with the equipment to determine its performance under both normal and abnormal test conditions.

Housings of thermosetting materials have generally been recognized for both portable appliances and for fixed wiring devices. Housings of thermoplastic materials have not been accepted for fixed wiring devices because of their combustibility and the relatively low softening temperatures of such materials. Thermoplastic materials have been accepted for portable appliance housings wherever the softening of the housing material would not result in a hazard to the user. Where such materials were relied upon to house live parts of portable appliances a series of tests was established to show that the housings (1) would not soften when placed on a steam radiator or other heated surfaces, (2) would not be broken by a fall from table height, (3) would not ignite or permit emission of flame or molten material under conditions of abnormal operation, and (4) would be self-extinguishing if ignited by an electrical failure. Some high acetyl cellulose acetate materials have been found to meet these requirements.

Barrier Materials:

Barriers are used in electrical equipment to provide increased air spacing or to provide mechanical separation of wiring from opposite polarity live metal parts. The materials are generally in the form of sheet or tubing and the requirements are somewhat less limiting than in the case of insulating material which serves as the sole support for live parts. For example vulcanized fibre has long been recognized as an acceptable barrier material although it is not accepted for sole support of live parts on the basis of its combustibility and tendency to be hygroscopic.

The use of cellulose acetate sheet for coil forms is a fairly recent development and it has been the subject of discussion with users on a number of occasions. The general test limit for most cellulose acetates and similar materials is 65 C, but coil designs are generally determined by the 90 C temperature limit for Class A insulation so that coil forms are required to show no adverse effect after operation with the coil at 100 C, the 10 C increase covering high operating ambient conditions.

Mounting of Live Parts:

The use of thermosetting materials such as the phenolics and ureas for the support of current-carrying parts of electrical equipment goes back to the early years of the century. Unfortunately the wide variations in performance of these materials are not well recorded. Experience has not indicated the need for more specific requirements, but when comparisons with other materials are made a great deal depends on the samples picked for comparative purposes. In general these thermosetting materials are relatively non-combustible in their molded form, they will not soften with increased temperatures and they will not soften with increased temperatures and they will not be adversely affected by temperatures of 150 C for a short period of time.

From the foregoing it is evident that the general class of thermoplastic materials cannot be classed with phenolic and urea materials and they have not been considered as acceptable for the mounting of current carrying parts. There are a number of special situations that should be mentioned in this connection:

(1) Attachment Caps: Polystrene and other materials were accepted for caps as a World War II substitute for phenolic composition and the practice has been continued because there has been no adverse field experience. Actually this is a special application where impact resistance is of great importance as evidenced by the fact that rubber plug caps are also recognized.

(2) Fluorescent Lampholders: The tombstone type of lampholder was made of the acetates and other materials as a means of eliminating breakage in shipment during World War II. Field experience in the postwar period both from the standpoint of lamp security and fire indicated that this use of thermoplastic materials was not justified by the slight mechanical advantage and recognition was discontinued over a year ago.

(3) Polyamides, etc.: There has been a limited use of nylon as a support for live parts based on its high heat resistance and self-extinguishing characteristics. Other materials having special characteristics are being investigated for special applications as the occasion arises.

(4) Polyesters: Polyesters range from thermosetting to the thermoplastic category. They can be made self-extinguishing although certain additions employed for this purpose are not stable at 150 C for long periods. It is likely that some new and lower temperature limit could be established for a material which is deficient in this respect although the temperature level should take into account high, ambient conditions.

Testing Procedure:

The various applications of plastic materials covered by the foregoing discussion involve testing of the final part as used in the equipment, but as indicated it is often necessary to test new materials for their general suitability in electrical applications. There are a number of points on which plastic material manufacturers and fabricators generally ask for additional information.

1. Sample—The preferred sample should be a production part from stock. Small sized parts can be assembled on rods, wires, or other mechanical means for flame tests. Additional test bars are useful and they are essential where specific production parts are not available.

2. Electrical Insulation—Most types of electrical insulating plastic materials have adequate dielectric strength for the purpose and simple dielectric tests are easily made.

3. Combustibility—Plastic materials range from fast burning to slow-burning to self-extinguishing to non-

combustible with the majority in the slow-burning range. The size of the test flame is an important factor and the five inch Bunsen burner flame with a 1½ inch blue cone has been used extensively for many years. A factor of considerable interest is the height of flaming above the point of flame application, a figure which has no particular relationship to the time of burning after flame removal.

When inhibitors are used to make a material self-extinguishing as in the case of chlorinated compounds, care should be taken that the inhibitors are not lost during normal service by migration and volatility.

4. Mechanical Strength—Field experience is the best test of mechanical strength, but reports are not often available and a test representing somewhat greater than normal damage conditions such as the drop test from table height, is often useful. Comparable mechanical tests with known materials are apt to be misleading unless the materials have similar characteristics.

5. Analysis—The whole performance of a new plastic material for a given use must be determined by tests along lines indicated in the foregoing. Then by comparison with similar tests on materials already recognized for the use an opinion is reached on the acceptability of the new material. There can be no outstanding weakness of the new material without compensating advantages where previously used materials have proven to be deficient. For example, outstanding dielectric strength does not balance greater combustibility for most uses because dielectric strength is rarely a weak point in the electrical plastic application. Similarly a new material cannot be considered acceptable if it is merely equal to existing materials at a number of weak points. The downward spiral of performance with such materials would lower requirements until many electrical devices would be operating at a marginal level—a possibility that is not as remote as it may seem. This viewpoint is not always shared by the manufacturer who has located a new plastic with a favorable price situation, but few objections have been offered concerning the general soundness of this approach when discussed with plastics materials engineers.

6. Marking—The marking of plastic materials for ready identification in the field has been a problem since the early use of the plastic materials in the electrical industry. The plastic materials manufacturer can rarely mark his product in any way that will be helpful to the product manufacturer. The molder or fabricator wants flexibility in his use of materials with the result that his markings even if provided are of doubtful value. The product manufacturer is unable to help in any way because he does not have the facts.

Some applications have had partial success in time:

1. Building wire is stamped with the type designation.

2. Thermoplastic tubing is stamped with a temperature designation.

3. A manufacturer of sheet insulating material although not a plastic used colored threads in the surface of the material.

4. Another manufacturer of sheet insulating material used an overall surface pattern of his trademark.

5. Consideration is being given to identification by a sharp melt point which is claimed as a distinctive characteristic of the specific formulation.

It is evident that a material having acceptable characteristics in a specific formulation could be recognized rather generally for the use if inspectors as well as engineers could recognize it readily by its appearance or by some other easily identifiable characteristics.

Conclusion:

In completing this outline of the viewpoint of Underwriters' Laboratories engineers toward plastic materials and their use in electrical equipment it should be pointed out that there are many other sides to the plastic picture beyond the scope of this paper as for example the hazards of storage and use and the fire protection hazards of plastic wall covering materials. Without attempting to go beyond the electrical application field it is hoped that these notes on our viewpoint will help to solve your problems and provide some small measure of recognition for the many helpful discussions and suggestions that we had from the members of your industry.

Properties and Processing of Rigid Vinyls

By C. E. Parks

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Unplasticized polyvinyl is difficult to process but is greatly superior in electrical and chemical resistance. A new rigid vinyl, easier to process, is opening new fields.

Polyvinyl chloride resin has been known for more than thirty years and many of its outstanding properties were recognized by research chemists. However, it is a very tough and bony material and no one at that time was able to process it for any useful purpose. About twenty years ago, through the work of Dr. Waldo Semon and others, it was learned that certain high boiling liquids would permanently soften this polymer and make it possible to process it on rubber equipment. This discovery has made possible the huge vinyl plastics industry which we have today.

Certain properties of polyvinyl chloride were lost when these plasticizers were added. The acid, alkali, solvent, electrical, heat and light resistant properties were inferior to the original polymer. Although it is recognized that the multitude of the present day uses for vinyls which require soft pliable materials would be impossible without plasticizers, on the other hand it may be possible to find just as many uses for the rigid unplasticized material when we are able to process it properly. This conception suggests two separate and distinct classifications and fields of application. It is recognized that there is an intermediate ground which is held by the "low-plasticized" vinyl plastics, which tends to merge the two divisions. One should not confuse the term "hard vinyls" as produced by reducing the plasticizer content, with "rigid vinyls" which are made by pro-

C. E. Parks

cessit[illegible] the resin entirely without plasti[illegible]zer. The "hard vinyls" still belong [illegible]n the plasticized classification becau[illegible] their physical and chemical properties are similar. They differ only in relation to the amount and types of plasticizers used. On the other hand, the "rigid vinyls" retain the unmodified properties of the pure polyvinyl chloride which are superior in every respect when articles of the greatest hardness, toughness and rigidity are desired.

An effort to capture these unique properties led to the development of the third classification of vinyl plastics. It consists of a large number of resins which are made by copolymerizing vinyl chloride with small amounts of various other monomers. By this method resins are produced which can be processed without plasticizers, but the fundamental properties are not normally equivalent to those of straight polyvinyl chloride. The usual co-monomers also act as modifiers which result in lower molecular weight resins and therefore reduce the heat distortion point, flexural strength, tensile strength, shock resistance, electrical resistance, as well as the chemical and solvent resistance.

A new high molecular weight polyvinyl resin has recently been developed which can be processed without plasticizer on conventional plastics equipment. Although it has been produced in commercial quantities and processed on production equipment, it is not yet available in large quantities. Under present emergency conditions, the new resin will be available only for the development of military and other essential applications.

PROCESSING

Unplasticized polyvinyl chloride has superior chemical and physical properties which should make it one of the outstanding rigid plastics. However, it is enjoying no more than 3% of the present market for thermoplastic materials. The potential uses for this unique polymer are so great that one may wonder why the actual consumption is so small. The answer to that question is very simple—it is nearly impossible to process. Most fabricators in this country are convinced that it cannot be calendered, extruded or molded satisfactorily without the addition of some plasticizer.

It has been carefully pointed out in the introduction that the addition of enough plasticizer to help processing will definitely impair the physical properties. The effects of small additions of plasticizer begin to show up in lowered end-use properties before they start to improve the processing conditions.

In Germany straight unplasticized polyvinyl chloride sheets and tubes have been used for large scale industrial fabrications. During World War II this was considered an essential industry since many of its applications supplanted critical metals. However, the high quality resins produced in this country are generally considered to be too dry and tough, even at high temperatures, to be usable without plasticizer. The new resin referred to earlier promises to be satisfactory for this purpose because it can be processed satisfactorily on conventional equipment and still retain its excellent properties.

The word "processing" is greatly overworked in writings pertaining to thermoplastic materials. It is used to describe all of the various operations which are employed to change dry resin into a usable form. Although it is possible to process some rigid vinyls **directly** into usable forms by extrusion, molding or calendering, it is not recommended for most applications. It is generally more satisfactory to do the initial work in the banbury or on a mill where the proper stabilizers, lubricants, fillers and colors can be added. The mechanical working which is received here is more important than it is in the soft plasticized stocks which flow and knit together much faster. After milling it is necessary to cut the sheets into small pieces for further processing, but rigid vinyls are so tough and horny that it is impractical to granulate after the stock is cold. Since the batch hardens very rapidly after removal from the mill rolls, it is difficult to handle large sheets and keep them hot enough for cutting.

A larger tuber which will extrude the unplasticized powder into small rods, and a chopper to cut them into short length, promises to be the best method for making granules. It is usually necessary to pass the rods through a short water bath to chill

PHYSICAL PROPERTIES OF WIRE INSULATION

Insulation Properties	Plasticized Vinyl (Standard Wire Insulation)	Rigid Vinyl (Geon 404)
Tensile Strength # sq. in.	2000-3000	6500-8500
Elongation—%	200-300	15-25*
Hardness—Durometer	65-95A	82D
Specific Gravity	1.3-1.4	1.35-1.45
Low Temp. Flex 2 hrs./°F. (6 turns around 0.3" mandrel) passes	-30° to -50°	-70°
Heat Shock—1 hr. 120°C.	OK	OK
Air Oven Aging 7 days @ 100°C. % Retention of Elongation	70-90	100
Cutting Resistance @ 50°C. (lbs. thru .032" wall) .025" conductor—Cutting resistance @ 70°C	10.5	47.5
Compression Strength @ 25°C.**** (lbs./2 in. length)	2500	8500
Deformation (1/32" wall, 1000 gm wt. on 3/8" foot) 1 hr. @ 120°C.	40-50%	25%
Abrasion Resistance** Taber Abrader (60 D2R) 5000 rev — weight loss	.25 gm	.085 gm
— volume loss	.185 cc	.060 cc

ELECTRICAL PROPERTIES OF WIRE INSULATION

Insulation Properties	Plasticized Vinyl (Standard Wire Insulation)	Rigid Vinyl (Geon 404)
Insulation Resistance megohms — 1000 ft. @ 50°C. — 1/32" wall	50-100	20,000-35,000
Dielectric Strength (v/mil) @ 25° in water 1/64" wall	700-900	1200-1300
1/32" wall	600-800	800-1000
Power Factor @ 1000 cycles @ 25°C.	.07-.09	.015-.02
Dielectric Constant @ 1000 cycles @ 25°C.	5-7	3.0-3.2
Loss Factor @ 1000 cycles @ 25°C.	.35-.6	.045-.064
Power Factor @ 1000 cycles @ 50° C.	.09-.11	.012-.017
Dielectric Constant @ 1000 cycles @ 50° C.	6-8	3.2-3.4
Loss Factor @ 1000 cycles @ 50° C.	.54-.88	.038-.058

* Jaw separation 1 inch/min.
**Runs on tensile sheets.
***Conductor broke.
**** Compression rate 0.2 inch/min.

the surface to prevent them from sticking together.

In the initial step, the most important point is immediate fusion under heat and pressure whether it be in the banbury, on the mill, or in whatever equipment is used. This quality is generally good for soft resins but very poor for the harder types. After fluxing, the batch should roll or flow enough over itself to produce thorough cohesion of particles which is indicated by a smooth, glossy sheet or banbury batch. A good rolling bank on the mill is an indication that the resin can be satisfactorily processed in supplementary equipment.

This is particularly true in the extruder and calender, but is not positive proof for injection molding. This method requires a type of flow which is not easily attained by unplasticized vinyls; the soft copolymers can be made to work by special compounding but the harder copolymers and the straight vinyl chloride polymers are not satisfactory.

All vinyl compositions require careful temperature control for proper processing. This is especially true when the compound contains no plasticizer. They require a relatively high temperature which must be accurately controlled between the softening point and the decomposition temperature. There is no wide range of allowable temperatures such as are permissable with other resins such as polyethylene, polystyrene and nylon. This has been a serious handicap to many processors who were unable or unwilling to meet the required conditions. The problem is further complicated by the fact that unplasticized stocks are subject to terrific frictional heat build up on processing.

The temperature requirements for rigid vinyls depend on the type of polymers used. In general, the processing temperature for an unplasticized resin is only 20° to 30°F higher than for the same resin with 50 parts of plasticizer. One of the early mistakes in rigid vinyl processing was the belief that a very high temperature is required. This aggravated the problem of stabilization and caused excessive sticking to the mill rolls.

Chemical Property Uses

Rigid polyvinyl chloride has outstanding chemical resistance which suggests uses in corrosive areas. Since the rigid sheets can be welded by the hot gas technique, it can be fabricated into fume hoods and duct work where most metals are unsatisfactory. Tanks to hold corrosive chemicals can be made of it in the unsupported form or as a liner for metal tanks. In the deep drawn and welded forms, such things as pitchers, trays, funnels, buckets, barrels, etc. can also be made and used in places where inert material is required.

Physical Property Uses

The great strength, light weight and breakage resistance or rigid polyvinyl chloride makes it suitable for instrument, typewriter and business machine cases, luggage, tote boxes, etc. The transparency and full range of beautiful colors make it desirable for structural and advertising purposes. Its ability to be drawn and molded to reveal the finest detail makes it suitable for topographical maps for military use.

Electrical Property Uses

The excellent electrical properties of rigid polyvinyl chloride suggest the following applications:

(1) Weatherproof line wire in which its good deformation and abrasion resistance, good low temperature and high dielectric strength are employed.

(2) As a primary insulation eliminating the need for a jacket in those applications where, because of the inherent deficiency of the primary insulation, a thin jacket (generally nylon) is applied as a second extrusion to impart abrasion and deformation resistance. Included in this category are military field wire and military aircraft wiring.

(3) For primary insulations where very high electrical properties are required, such as in television lead in wire, communication and signal wires which cannot be met by plasticized vinyls.

(4) For other military applications such as radio hook-up wire to meet specification Mil-W-76-A and Spiral 4 wire which require excellent physical as well as electrical properties.

(5) For such uses which require compositions that do not contaminate the primary insulation, as coaxial cable jacket.

(6) For those Navy cables of the reduced diameter types which require a non-exuding jacket at elevated temperatures.

Undoubtedly, other uses in the wire and cable as well as other fields, will be developed as experience and knowledge is gained about rigid polyvinyl chloride.

Conditioning Phenolics

(Continued from page 15)

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Section Notes

Buffalo Section met on January 26 to see the movie and hear the discussion on the Bell Rocket Ship. Sterling Molders Inc. provided a display and Hi Nathan gave a summary of the Technical Conference in New York. New Officers for the year are: president, James V. Vevirit; vice president, J. Clarke Cassidy, Jr.; secretary, John E. Miner; treasurer, Eugene Roeck.

"Electroplating of Plastics" was discussed by Jerome Weller at the Upper Midwest Section meeting on January 8. Mr. Weller is in charge of research and development of electroplating at Brown & Bigelow. Mr. James E. Corbin's "Plastics in the Tape Industry" proved most interesting at the previous meeting. New officers for the year are: president, Paul W. Felt; vice president, J. H. Kugler; secretary-treasurer, W. Mahle.

The Chicago Section met with the S.P.I. at the Builders Club to hear Lewis B. Connelly, Tennessee Eastman Corp., discuss "The Use of Tenite to Combat Corrosion in the Oil Country" at the January 10th meeting.

The Rochester Section met on January 15 to hear George W. Volckhausen, Owens-Corning Fibreglas Corp., discuss "Fibreglas with Polyester Resins."

On January 15th the Philadelphia Section heard a discussion by A. A. Hutchings and S. H. Greenwood on the highlights of their current automatic molding equipment. The program was arranged by the F. J. Stokes Machine Co.

The Rhode Island and Southeastern Massachusetts Section met on January 10th to hear Mr. M. A. Nichols, Manco Products Co., discuss "Why Beryllium Copper?"

The Saint Louis Section heard Mr. Stanley R. Melvin, Monsanto Chemical Company, Springfield, Mass., discuss "Improvement of Thermoplastic Products by Post-Molding Treatments" at their January 23rd meeting. The Technical Committee presented Mr. Robert Klorer of Spaulding Fibre Company in a discussion of post-forming of phenolic sheets.

The first Toronto meeting of the New Year was on Tuesday, January 30th. It was held in the Walker House Hotel, 122 Front St. East, Toronto. The speaker was Mr. Lewis B. Con-

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nelly Technical Sales Representative, Tennessee Eastman Company, St. Louis, Missouri. The subject of Mr. Connelly's address was the "Use of Tenite to Combat Corrosion in Oil Country." He illustrated his talk on the subject with a 16 mm. movie made on the scene of an installation of Tenite Oil field tubing. Eric Huggins summarized the highlights of the New York S.P.E. Conference at this meeting.

SOUTH TEXAS ELECTS FUKAL

Alfred F. Fukal, industrial designer, has been elected president for the coming year of the South Texas Section of the Society of Plastic Engineers.

Formerly in charge of design and development of the Plastics Division, Continental Can Company, and on the faculty of the School of the Art Institute of Chicago, Mr. Fukal located in Houston in 1949. In addition to practicing his profession, he is on the teaching staff of the University of Houston. Mr. Fukal is the holder of numerous patents and has developed and designed many household appliances and tools. Among the better known plastics items to his credit is the all plastic AIR FLIGHT circulator manufactured by the W. W. Welch Company.

Other officers elected include L. D. Blackwell, vice president, part owner of Blackwell Plastics Company, Houston, and Phil Shay, secretary-treasurer, Houston tool engineer and consultant.

NEW ORLEANS HAS JOINT MEETING

By LEON GODCHAUX II

At its regular monthly meeting held January 4, 1951, the New Orleans Chapter of the Society of Plastic Engineers, elected officers for the year 1951, as follows:

President, Mr. Frank Perschall; Vice-President, Mr. Paul Oswald; Secty.-Treas., Mr. Leon Godchaux II; Chapter Representative, Mr. Harold Levey.

The membership was advised of the joint meeting to be sponsored by the Society of Plastics Engineers, Inc., the American Society of Safety Engineers, and the American Society of Mechanical Engineers, said meeting to be part of the program of the annual meeting of the Louisiana Engineering Society, of which the New Orleans Chapter of the Society of Plastics Engineers is an affiliate. The paper to be presented will be "Safety Engineering in Retrospect and Prospect," by Dr. William P. Yant, National President A.S.S.E., Director of Research and Development, Mine Safety Appliance Co., Pittsburgh, Pa.

MIAMI VALLEY ACTIVITY VARIED

By JOHN L. RUSSELL

Miami Valley Section feels highly honored in the selection by the National Organization at the recent Technical Conference of its former President and National Director, Walter Oelman, as National Secretary for 1951. Walter has been one of our most active members and staunchest supporters and our best wishes go to him in his new undertaking.

Miami Valley was very well represented at New York. Martin Kasch, our new Section President, and Victor Reiling, Works Manager from Kurz-Kasch, Inc., Byron Nelson, Miami Valley Vice-President, Robert Chollar and G. J. Wilson, National Cash Register Co., Carl Weber, M-V Secretary, and Carl Ackerman, and Paul Best, Crosley Div., Avco Corp., Walter Oelman, Standard Molding Corp., John Brierley, Bakelite Corp., and Gil Carpenter, Tennessee-Eastman Corp.

President Martin Kasch has announced his list of Committee appointments for the year. They are Program Chairman, Carroll Jensen, Dayton, and Ralph Backscheider, Cincinnati; Fellowship, Merle Nelson; Professional Activities, G. J. Wilson; Credentials, Carl Weber; Membership, John Brierley; and Publicity, John L. Russell.

Carroll Jensen was in charge of the February 1st meeting held at the Peerless Pantry in Miamisburg, O. A dinner at 6:30 p.m. was followed by a business meeting and the principal talk of the evening by Mr. A. R Morse, Injection Molders Supply Co. His topic was "Production Aids for the Injection Molders."

All of our members wish to express sincere appreciation to the management of the Crosley Div., Avco Corp., Cincinnati for their very fine effort as host for the January 4 meeting. Carl Ackerman, pinch-hitting for Carl Weber, served as master of ceremonies and introduced Works Manager William Graham, who spoke of Crosley's activities, growth and future plans. Harold Brouse, our fellow SPE member, gave us a picture of their electronic accomplishments and Ralph Benson showed some of the various Crosley household appliances and the extent of plastics used in their manufacture. A chicken dinner in the Company dining room had previously started the evening's program off in fine style. Later a trip was made through the television and radio production line and an opportunity to view the company's entire line of products. The section owes the Co-Chairmen, Carl Weber and Merle Nelson a vote of thanks for arranging such a splendid program to initiate 1951.

Mel Kemper, one of Miami Valley's charter members and formerly associated with Inland Div., General Motors Corp., Dayton, Premium Plastics, Inc., and Improved Paper Machinery Co. is now with the American Insulator Corp., of New Freedom, Pa. His address is 309 Lamont Dr., Dayton 9, Ohio.

QUEBEC OFFICERS PLAN FUTURE

By E. PETER HERSEY

The annual meeting of the Quebec Section of S.P.E. was held in Montreal on Dec. 27th 1950.

It is difficult to measure the success that we have had during the past year. If one considers attendance at the meetings as a measure of success then I believe you will agree that we have had a mediocre year. On the other hand let's consider the men who addressed our section and then I am sure you will agree that a worth while and successful job was accomplished, at least in part.

Considerable thanks must be extended to Mr. Graham Rea of Monsanto Canada Limited and Mr. Earnie Suter of Aviation Electric Company for the work that they have done during the past year.

The officers for the Quebec Section of S.P.E. during the year 1951 will be: Pres., E. Peter Hersey; Vice Pres. and Treas., E. Suter; Sec., R. G. Rea.

The first Canadian Section of S.P.E. was organized four years ago in Montreal, Quebec. In the past the President and Secretary virtually did all the work of organizing the seven technical meetings that are held during a year. This year we are going to concentrate on committees and the future success of the section will be the responsibility of these committees.

During the past few months considerable thought has been given to the possibility of S.P.E. dinner meetings rather than a purely technical session. At the present time we intend to compromise by announcing a convenient restaurant where we can get together on a voluntary basis for dinner and social hour before the technical session which will follow at our usual meeting place.

The next meeting of S.P.E. took place on Wednesday, January 31st. At that time, Mr. M. A. Nichols of Manco Products addressed our section on "The Use of Beryllium Copper in Molds."

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MORSE AT NEWARK

Committees Are Appointed

By JOHN GROESBECK

The January dinner meeting of the Newark Chapter of the Society of Plastic Engineers was held on January 10th at the Military Park Hotel, Newark. Approximately 70 members and guests were present to hear Mr. A. R. Morse, Sales Manager of the Injection Molders Supply Co., talk on "Production Aids For Injection Molders."

The business meeting preceding this very interesting talk was featured by the announcement by President Simmons of the following committee chairmen for 1951:

Publicity, John Groesbeck, American Hard Rubber Co.; Credentials, Ed Spitzig, Newark Die Company; Educational, Carl Frosch, Bell Telephone Labs.; Membership, Dick Leiter, Celanese Corporation; House, Charles Sanders, Dillon-Beck Mfg. Co.; Program, Bill Willert, Hartig Engineering Co.; S.P.E. Reporter, Anthony Naturale, Thomas Mfg. Company.

Out of town guests welcomed were Stanley Bindman of Jamison Plastics; R. E. Franklin of Franklin Engineering Co., Ann Arbor, Michigan; Saul Blitz of Noma Electric Co., and Bruno Wessinger who was co-chairman of registrations for the annual Technical Conference held Jan. 18th to 20th at the Hotel Statler in New York.

Table favors were napkin clips donated by Bestway Products. Door prizes were donated by the Dow Chemical Company and won by John Wittek and Ed Rowan.

Mr. Morse opened his talk by a brief account of his personal experiences with molding machine manufacturers and custom molders, which convinced him of the need of customer molders for properly-engineered accessories which would tend to stabilize molding conditions over a long period of time. His talk was illustrated by slides which were well received by the audience. An all-welded heating cylinder which was considered a big improvement over the conventional type was discussed from the standpoint of increased production at a lower heat input, examples of which were reported by custom molders present.

A mold temperature control unit built by Meridien Plastics to sell for less than $1000.00 was discussed. It is evident that maintenance of the correct mold temperature for a particular application is receiving the consideration it deserves by more custom molders.

Among other items featured by Mr. Morse were injection machine nozzles incorporating principles of restricted gating, various types of gate cutters, and a material transfer unit for high hopper machines. It was emphasized that the various products developed by the Injection Molders Supply Company resulted from ideas received from custom molders in connection with problems experienced by them. Be that as it may, it is this reporter's belief that the industry owes a real vote of thanks to Mr. Morse for the outstanding job of service he is doing.

The February meeting of the Newark Section was held on February 14th. In addition to the speaker announced last month, Mr. Carl N. Gardiner, Office of Quartermaster General, spoke on "Military Applications of Plastics."

The March meeting of the Newark Section will be held on March 14th. The speaker will be Mr. Willard De Camp Crater, Naugatuck Chemical Company, who will talk on "The Properties and Uses of Marvinol, Kralastic and Enrup."

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Penn Notes

By PAUL ROCHE

Jens Pedersen has announced the organization of a new company, Pedersen Machine Shop, specializing in plastics molds. Mr. Pedersen is well known in local plastic circles for his capable tool work, having been associated formerly with Anson Tools and Gages as well as Perry Plastics, Inc. The address of Pedersen Machine Shop is 1946 E 12th St., Erie, Pa.

Mr. R. B. Anderson, manager of Anson Tools and Gages of Erie, Penna., announces the addition of a large Hyrodel duplicator to their recently extended facilities. Specializing in molds of all sorts, this company is expanding into a larger class of work. Anson's now has a heavy schedule of commercial and defense type work.

By the time this issue goes to press Wayne J. Osborn, Supt. of Perry Plastics, Inc. of Erie, will have rejoined the common people in Erie. At this writing he is basking with other well-heeled tycoons in Florida.

Molderscope

(Continued from page 6)

level up at least to the level of the old hopper. It takes time to dry thermoplastics. One pass under an infra-red light just won't do it. Some of the acetate appearing on the market today is so impregnated with moisture that extended oven drying and heating with a hopper heater will barely clear it. In general, 5-8 hours in one of the top quality ovens like the Brosites, the Despatch or the Lydon is required, but the D & W gives a good account of itself in most cases. As a preheater, the hopper heater has given marked improvement in the performance of certain machines on certain jobs.

Mr. Stanford H. Shaw has been appointed Sales Manager of Shaw Insulator Company, and **Mr. George A. Johns** has been retained as Sales Consultant.